Shells of Land and Water

by Frank Collins Baker

594
B1675 5122

594
B1675 5122
Ba ker, Frank Collins
Shells Of Land and Water

DATE DUE	BORROWER'S NAME	ROOM NUMBER
OCT 31 '74	Margie Maloney	3249
NOV 21 '74	Renewed NOV 21 RECD	
OCT 20 '74	OCT 18 RECD	4/0
	To be mended	

LIBRARY
College of St. Francis
JOLIET, ILL

University of St. Francis
GEN 594 B1675
Baker
Shells of land and water
3 0301 00021572 9

SHELLS OF LAND AND WATER

FROM GOL. CHI. ACAD. SCIENCES.

COWRY SHELLS.

COPYRIGHT 1902, BY A. W. MUMFORD, CHICAGO.

Cypraea exanthema (Half grown.)
Trivia solandri (California).
Cypraea erosa (Indian Ocean).
Cypraea spadicea (California).
Cypraea talpa (Pacific Ocean).

Cypraea exanthema (Young).

Cypraea mus (Europe).

Cypraea exanthema (Florida).
Cypraea annulus (Indian Ocean).
Cypraea lurida (Mediterranean Sea).
Cypraea moneta (Philippines).
Cypraea histrio (Indian Ocean).

SHELLS OF LAND AND WATER

A FAMILIAR INTRODUCTION TO THE STUDY OF THE MOLLUSKS

BY

FRANK COLLINS BAKER

CURATOR, THE CHICAGO ACADEMY OF SCIENCES

ILLUSTRATED

CHICAGO

A. W. MUMFORD, PUBLISHER

1903

Copyright, 1903
By FRANK COLLINS BAKER

The Lakeside Press
R. R. DONNELLEY & SONS COMPANY
CHICAGO

TO ALL STUDENTS OF NATURE

WHO GATHER HER SECRETS BY OBSERVATIONS
IN FIELD, FOREST, AND WATER
THIS VOLUME IS DEDICATED

5122

"The more things thou learnest to know and to enjoy, the more complete and full will be for thee the delight of living."— PLATEN.

CONTENTS

	PAGE
The Home of the Clam	1
A Day with the Pond Snails	11
Snails of Pond, River, and Brook	18
In the Home of the Snail	25
An Evening with the Aquarium and Snailery	34
How Snails Eat	39
Snails of the Forest and Field	46
How to Preserve a Collection	55
On the Beach at Low Tide	61
The Oyster and Its Relatives	69
In Search of the Drill and Periwinkle	83
Some Snails of the Ocean	94
The Cowries, Shell Money, and the Rock Shells	106
Cones, Basket-Shells, and Other Marine Snails	115
In Search of the Squid	125
The Nautilus and Its Relatives	132
The Classification of Shells	144
Some Books to Study	148
Glossary of Technical Terms	153
Conclusion	164
Index	167

LIST OF FULL-PAGE ILLUSTRATIONS IN COLOR

PAGE

COWRY SHELLS - - - - - - Frontispiece
Cypræa annulus, Cypræa erosa, Cypræa exanthema (half grown), Cypræa exanthema (young), Cypræa exanthema (full grown), Cypræa histrio, Cypræa lurida, Cypræa moneta, Cypræa mus, Cypræa spadicea, Cypræa talpa, Trivia solandri.

POND SNAILS AND RIVER SNAILS - - - - - 18
Ampullaria depressa, Angitrema verrucosa, Campeloma subsolidum, Limnæa megasoma, Limnæa stagnalis, Melania tetrica, Physa gyrina, Planorbis trivolvis, Pleurocera elevatum, Vivipara contectoides.

LAND SHELLS - - - - - - - - 46
Acavus hæmastomus, Achatinella, Cerion microstoma, Clausilia macarana, Cochlostyla intorta, Cyclophorus appendiculatus, Drymæus multilineatus, Epiphragmophora fidelis, Glandina truncata, Helix nemoralis, Helix pomatia, Liguus fasciatus, Nanina lamarkiana, Omphalina fuliginosa, Polygyra albolabris, Polygyra profunda, Strophocheilus chiliensis.

THE OYSTER AND ITS RELATIVES - - - - - 69
Cardium isocardia, Cytherea lupinaria, Lampsilis luteola, Mytilus edulis, Ostrea lacerans, Pecten dislocatus, Pteria radiata, Spondylus imperialis, Tellina radiata.

SOME SNAILS OF THE OCEAN - - - - - - 94
Bulla ampulla, Cerithium aluco, Crepidula fornicata, Fissuridea listeri, Haliotis assimilis, Harpa nobilis, Littorina angulifera, Mitra pontificalis, Nerita peloronta, Strombus auris-dianae, Terebra lamarckii, Turbo petholatus.

ROCK SHELLS - - - - - - - - 106
Murex adustus, Murex axicornis, Murex bicolor, Murex pomum, Murex radix, Murex ramosus, Murex tribulus, Murex trunculus.

MARINE SHELLS - - - - - - - 115
Buccinum undatum, Cassis flammea, Chiton squamosus, Conus marmoreus, Cypræa pantherina, Fasciolaria distans, Ianthina communis, Lottia gigantea, Nassa glans, Oliva irisans, Tritonium olearium, Voluta musica.

CEPHALOPODS - - - - - - - - 132
Beak of Octopus, Paper Nautilus (Argonauta tuberculata), Pearly Nautilus (Nautilus umbilicatus).

ALPHABETICAL LIST OF ILLUSTRATIONS

HALF-TONES AND LINE ENGRAVINGS

PAGE

Amnicola limosa, Dorsal and Ventral Views of - - - 16
Ampullaria depressa, Animal of - - - - - 21
Anodonta, The Glochidium of - - - - - 7
Ark Shell, The Interior of, *Arca pexata* - - - - 68

Basket Shell, A - - - - - - - 121
Beach at Low Tide, The - - - - - - 60
Butterfly, A Common Sea, or Pteropod, *Hyalæa trispinosa* - - 124
Byssus of the Black Mussel, *Mytilus edulis* - - - - 63

Calyculina transversa, Shell, Foot and Siphons of - - 9
Cameo of Columbus Cut in a Helmet Shell - - - - 116
Campeloma, Animal of - - - - - - 16
Carrier Shell, A, *Xenophora conchyliophorus* - - - - 101
Castor-oil Shell, A, *Ricinula ricinus* - - - - 114
Cerion chrysalis in Motion - - - - - - 48
Chama arcinella - - - - - - - 78
Clam, Fresh-water, A Crawling - - - - - 5
Clam, Fresh-water, Interior of the Shell of a - - - 3
Clam, Fresh-water, Parts of the Shell of a - - - - 2
Clam, Fresh-water, Section of a - - - - - 7
Clam, Fresh-water, Section of the Shell of a - - - - 56
Clam, Fresh-water, The Right Valve Removed - - - 5
Clam, Hen-, A Common, *Spisula solidissima* - - - - 78
Clam, Interior of the Right Valve - - - - - 64
Clam Shell, Section of a - - - - - - 4
Clam, Soft-shelled, Section of the - - - - - 65
Clam, Soft-shelled, with the Left Valve Removed - - - 66
Clams, Soft-shelled, Buried in the Mud, *Mya arenaria* - - 62
Cochlicopa lubrica - - - - - - - 31
Collecting Locality, A Poor - - - - - 124
Collecting on the Shore of a Lake - - - - - 10
Columbus, Cameo of, Cut in a Helmet Shell - - - 116
Cone, The Textile, *Conus textile* - - - - - 118
Cowry, The Lynx, *Cyprœa lynx* - - - - - 109
Crab, The Hermit, in a Shell - - - - - - 92

PAGE

Cuttlefish, *Sepia officinalis* - - - - - - 141
Cypræa tigris, The Crawling Animal of - - - - 107

Drill and Periwinkle, The Rocky Home of the - - - 82
Drill, Method of Boring of a - - - - - - 87
Drill, Shell of the, *Urosalpinx cinereus* - - - - 84
Dredge, A Marine - - - - - - - 89
Dredging, Method of - - - - - - 90

Egg Mass of Physa gyrina - - - - - - 36

File-shell, A Common Chinese, *Lima squamosa* - - - 74

Glochidium of the Anodonta - - - - - - 7

Hare, A Sea, *Aplysia depilans* - - - - - 104
Harp Shell, A Beautiful, *Harpa ventricosa* - - - - 104
Helmet Shell Cameo of Columbus - - - - - 116
Hen-clam, A Common, *Spisula solidissima* - - - - 78
Hermit Crab in a Shell - - - - - - 92

Jaws of Land Snails - - - - - - 41, 43
Jingle-shells, One of the, *Anomia simplex* - - - - 73

Lightning Shell, The Common, *Fulgur canaliculatus* - - - 91
Limnotrochus thomasi, Shell of - - - - - 22
Limpet, A, *Patella longicosta* - - - - - - 95
Limpet, Fresh-water, *Ancylus rivularis* - - - - 34
Limpet, River, *Ancylus rivularis* - - - - - 14
Littorinas, A Good Locality for - - - - - 100

Maiden Shell, A, *Ancilla glabrata* - - - - - 119
Melongena corona, A Marine Snail - - - - 122
Mollusk, A Deep-water, *Calliostoma bairdii* - - - - 88
Mollusks Can Always Be Found, Where - - - - 54
Mollusks, Where Fresh-Water, Live - - - - - 143
Money, Primitive Shell - - - - - - 110
Mussel, The Byssus of the Black, *Mytilus edulis* - - - 63

Nautilus, The Pearly, *Nautilus pompilius* - - - - 133

Octopus tuberculatus - - - - - - - 136
Omphalina fuliginosa - - - - - - 33
Oyster, The Hammer-head, *Malleus vulgaris* - - - - 76

Paper Sailor, The, *Argonauta argo* - - - - - 135
Periwinkle, Anatomy of the, *Littorina littorea* - - - - 86
Periwinkle, The Rocky Home of the Drill and - - - 82
Physa, Animal of - - - - - - - 14

PAGE

Physa gyrina, Egg Mass of - - - - - - 36
Pleurocera elevatum, Shell of - - - - - 15
Pleurotoma babylonia - - - - - - 118
Polygyra tridentata, Radula of - - - - - 41
Pteropod, A Common, or Sea Butterfly, *Hyalæa trispinosa* - - 124
Pupa Shell, Aperture of - - - - - - 29
Purple Shell, A, *Purpura lapillus* - - - - - 113

Radula, Diagram of the Teeth on the Molluscan - - - 42
Radula of a Land Snail, Section of - - - - 42
Radula of Polygyra tridentata - - - - - 41
Rissoa costata, Young of - - - - - - 93
Razor Shell, *Ensis directus* - - - - - - 79
Razor Shell with Foot and Siphons Extended, *Ensis directus* - 67

Shankh of the Hindoos, *Turbinella pyrum* - - - - 120
Slug, A Sea, or Nudibranch, *Dendronotus arborescens* - - 123
Slug or Snail without an External Shell, *Limax flavus* - - 51
Snail, A Brazilian, *Bulimus oblongus* - - - - - 47
Snail, A Carnivorous Land, *Circinaria concava* - - - 37
Snail, A Common European Land, *Vitrea cellaria* - - - 46
Snail, A Common Land, *Gastrodonta ligera* - - - - 37
Snail, A Common Land, *Polygyra palliata* - - - - 25
Snail, A Crawling Pond, *Limnæa mighelsi* - - - - 35
Snail, A Marine, *Melongena corona* - - - - - 122
Snail, A Minute Land, *Pupa* - - - - - - 29
Snail, A Small Pond, *Limnæa desidiosa* - - - - 11
Snail, Animal of a Pond, *Limnæa mighelsi* - - - - 12
Snail, Apple, Shell and Operculum of the, *Campeloma decisum* - 15
Snail, Apple, Viewed from Above and in Front, *Vivipara intertexta* - 17
Snail, Diagram of the Animal of a Land - - - - 40
Snail, Diagram of the Buccal Organs of a Land - - - 39
Snail, Foot, Mantle and Tentacles of a Pond - - - 36
Snail, Fresh-water, A Minute, *Pomatiopsis lapidaria* - - - 23
Snail, Mouth Parts of a Pond, *Limnæa reflexa* - - - 45
Snail or Slug without an External Shell, *Limax flavus* - - 51
Snail, Orb, *Planorbis* - - - - - - 13
Snail, Parts of the Shell of a Pond - - - - - 11
Snail, Section of the Radula of a Land - - - - 42
Snail, Tadpole, Animal of, *Physa gyrina* - - - - 36
Snail, Teeth and Jaw of a Land, *Polygyra pennsylvanica* - - 41
Snail, Teeth of a Pond, *Limnæa caperata* - - - - 43
Snail, The Forest Home of the - - - - - 50
Snail, The Solitary, *Pyramidula solitaria* - - - - 32

PAGE

Snail, The Violet Sea, *Janthina fragilis* - - - - 115
Snail, White-lipped, Animal of the - - - - - 27
Snail, White-lipped, Shell of the - - - - - 26
Snail without an External Shell, *Limax agrestis* - - - 27
Snails, Four Species of Minute Land - - - - 30
Snails, Jaws of Land, *Polygyra thyroides and Limax flavus* - - 43
Snails, Left-handed Pond, *Physa gyrina* - - - - 13
Snails, Orb, The Foot of Each of Four Species - - - 38
Snails, Where Pond, Delight to Dwell - - - - 24
Spirula lævis - - - - - - - - 135
Squid, A Giant, *Architeuthis princeps* - - - - 139
Squid, Anatomy of a Female, *Loligo pealii* - - - - 130
Squid, Beak of a - - - - - - - 128
Squid, Diagram of the Body of a, *Loligo pealii* - - - - 127
Squid, Pen or Internal Support of a - - - - 129
Squid, The - - - - - - - - 137
Squid, Sucker of a, *Loligo pealii* - - - - - 128
Strombus gigas, Shell and Animal of - - - - - 102
Succinia ovalis, Crawling - - - - - - 31

Tagelus gibbus, Foot and Siphons of - - - - - 67
Teeth of a Pond Snail, *Limnæa caperata* - - - - 43
Teeth of a Water Breather, *Amnicola limosa* - - - - 44
Teeth, Diagram of the, on the Molluscan Radula - - - 42
Tellen Shell, An English, *Gari vespertina* - - - - 71
Teredo navalis, Animal of the - - - - - 80
Tide, The Beach at Low - - - - - - 60
Tooth Shell, *Dentalium elephantinum* - - - - 94
Top-shell, The Common, of the Mediterranean Sea, *Calliostoma zizyphinum* 97
Tray of Specimens - - - - - - - 58
Tridacna squamosa - - - - - - - 70
Trumpet Shell, The, *Tritonium tritonis* - - - - 123
Tun Shell and Animal, *Dolium perdix* - - - - - 117

Veliger larva - - - - - - - 93
Venus Comb, *Murex tenuispina* - - - - - - 111

Watering-pot Shell, *Aspergillum vaginiferum* - - - 81
Weirs, Fisherman's - - - - - - - 125
Whelk, The Black, *Chrysodomus antiquus* - - - - 122
Winkle Shell of the New England States, *Fulgur canaliculatus* - 91

Young of Rissoa costata - - - - - - 93

PREFACE

Living in the woods and in the ponds and streams about us are thousands of creatures, large and small, which are seldom observed, and rarely understood, and are, moreover, often thought too trivial for serious contemplation. Many people when looking at a mollusk will say, "O that's only a clam, or a snail," but if they are asked how the snail grew, or where it lives, they are utterly at a loss to answer.

The author has been frequently surprised by the careless question of some otherwise intelligent person, when he has been exhibiting the shell of some interesting mollusk: "Well, really, now, was that thing ever alive?" And the surprise of others when told that there are such animals as land snails is amazing, to say the least. It is to be earnestly hoped that such a condition of things will soon be changed by the light of knowledge.

Nature study has now become an established part of the curriculum of all schools, graded and higher, and no apology seems necessary for the appearance of this volume. For reasons which the author has acquired through his connection with the public, as custodian of a public museum, the pages which follow are couched in language somewhat different from the general books on nature which are being published. He believes that the narrative form will be more pleasing than any other style, and will bring the subject closer to the reader.

The plan of the work is as follows: Professor Parker is a teacher of biology in a university in which Harry and George are students. Howard is a young man, not attending school, but intensely interested in nature. The narrator is a post-graduate student, pursuing special studies. Professor Parker and the narrator are ardent conchologists, and the Professor has interested the three young men in the subject. In the chapters which follow, the quartette of conchologists visit the woods, fields, lakes, and seashore with Professor Parker, who instructs them in the various phases of the science. Local and other museums are visited in the search for knowledge, and the summer's work terminates in the formation of a conchological club. It is the hope of the writer that the use of this method may suggest to some teachers of nature, by little excursions into the country, a new way of interesting and instructing their pupils.

Each chapter of this volume treats of a definite branch of the subject, and all information is given which is necessary for the amateur. In the descriptive chapters on the different families of the Mollusca no attempt has been made to even approach completeness, only a simple outline being given of the facts concerning the most important families. Those who would know more concerning these lowly creatures (and the writer earnestly hopes that all who read this book will have such a desire) are referred to the chapter on "Some Books to Study."

In the preparation of those chapters devoted to visits to the museums, the writer has drawn upon all available books for information, and he cannot justly claim the authorship of these chapters, although the language and sequence are his, and for these he is responsible. The subject-matter of these chapters was also published in part in recent volumes of "Birds and Nature." The black and white cuts in the text have been carefully selected, and sufficiently illustrate the subject-matter of each chapter. The colored plates illustrate some of the principal families of mollusks.

It is the author's desire that this volume may be the means of stimulating an interest in this neglected but intensely interesting type of life, and if such should prove to be the case, he will feel amply repaid for time and trouble incident to its preparation.

The author believes that clubs should be formed for the study of nature, and in the present volume the formation of a club devoted to the study of mollusks is described. There are many clubs or societies which have for their object the study of botany, entomology, ornithology, and microscopy, but there are very few devoted to the study of the lowly mollusks. These animals should be of particular interest, because of their beauty, the ease with which they may be collected, and especially because their study and acquisition take the student into the fields, the woods, and beside the streams, and give him a wider conception of Nature and her laws.

FRANK COLLINS BAKER.

CHICAGO, ILLINOIS, June 1, 1903.

ILLUSTRATIONS AND ACKNOWLEDGMENTS

The colored plates are photographed from specimens loaned by The Chicago Academy of Sciences, and have been previously published in "Birds and Nature," Volumes VII, IX, and XII. The full-page half-tones are from negatives by Mr. Frank M. Woodruff, Mr. T. H. Purple, and Professor Alja R. Crook. A number of the line engravings and several of the half-tones in the text are from the works of Tryon, Woodward, Binney, Dall, Verrill, Morse, Prime, Lankester, Brooks, Hyatt, Gould, Goode, and Kunz. Several of these have been published in the Bulletins and Reports of the United States Fish Commission. Acknowledgment is made for these severally in the descriptions of each illustration. To these volumes the author desires to express his indebtedness, and also to The Chicago Academy of Sciences for the loan of various cuts which appeared in "The Mollusca of the Chicago Area." When not otherwise stated, the line engravings were from drawings made by the author especially for this work.

The nomenclature used is mainly that of Dr. William H. Dall, of the United States National Museum, and Dr. Henry A. Pilsbry, of the Academy of Natural Sciences of Philadelphia.

THE HOME OF THE CLAM

One morning in June, Professor Parker awakened our quartette of amateur conchologists at the early hour of five o'clock, and bade us prepare for a day's outing in search of fresh-water clams and snails. After hastily eating breakfast and packing a good lunch, for shell-collecting makes one very hungry, we left the house and boarded the cars for a ride of eighteen miles, which carried us to a large lake south of the city of C——.

The ride through the country in the early morning air was very exhilarating. A cool breeze blew across the open prairie, and wafted to our nostrils the sweet incense of early summer. After an hour's ride we reached the village of W——, and alighted from the car. A walk of fifteen or twenty minutes over a stretch of swampy prairie brought us to the edge of the large lake, which was our destination.

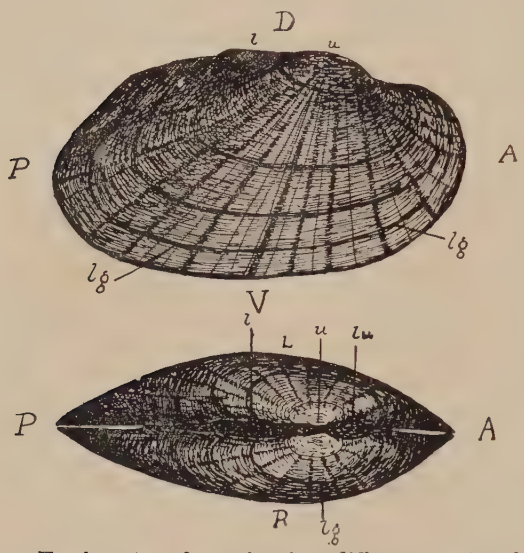
The lake at this point was shallow and bordered by cat-tail flags and rushes. The bottom was muddy and peculiarly adapted to the life of clams and snails. The water contained a large amount of lime held in solution, thus furnishing the material necessary for the building of the shells. This body of water was very beautiful, being several miles long and nearly a mile wide. In some places the bank sloped down to meet the water, which was overhung by tall trees, while in other places it was low, marshy, and reed-bordered. Here the dragon-flies flitted to and fro in search of prey, and the water was alive with whirligig-beetles, water-boatmen, and water-striders, the last being those strange, spider-like insects which appear to walk upon the surface of the water. As we went along the bank near the swampy portion of the lake, a large bittern started up and flew away in one direction, while in another, dropping from a nearby tree, a kingfisher uttered its shrill cry which sounded like a watchman's rattle.

Our collecting outfit consisted of a market-basket for carrying large specimens of clams, and in addition to this, each member of the party carried a fishing-basket. In this were stored several wide-mouthed, two-ounce bottles, one of which was filled with alcohol for preserving the soft animal. There were also some homœopathic vials for minute shells, a pair of sharp-pointed tweezers, a flat-bladed knife, and a small dipnet

5122

made of wire netting and attached to a long handle, jointed like a fish-pole. This net was of great value in securing specimens which were beyond the reach of the arm and in bringing up those species which live on a muddy bottom in rather deep water. Professor Parker had provided a two-quart pail for the purpose of carrying home some of the living snails and clams.

We prepared for our first collecting at a point in the lake where the shore was sandy and gradually sloped into deep water. The bottom was thickly dotted with little projections sticking out of the sand and mud. Harry, who was our most energetic collector, having removed his shoes and stockings, and having rolled up his trousers, waded into the water, and brought to us a handful of these objects which proved to be fresh-water clams, or *Unios*, like those pictured in the accompanying figure.



Fresh-water clam, showing different parts of shell. Upper figure, right valve exterior; lower figure, both valves viewed from above; A, anterior end; P, posterior end; D, dorsal margin; V, ventral margin; R, right valve; L, left valve; l, ligament; lg, lines of growth; lu, lunule; u, umbo.

The shells were a rich, yellowish green color, with rays of dark green extending from the umbones to the ventral margin. Some of the specimens were beautifully polished, while others were covered with a hard incrustation of mud at one end. Howard, who was a beginner, and knew little about mollusks, asked what the shell was made of and how it opened.

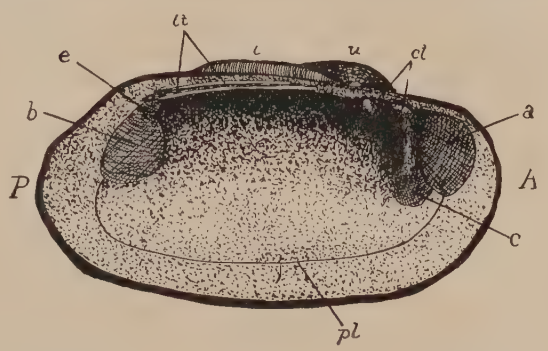
As we were all a little tired by our walk over the swampy ground near the lake, we sat down upon a grassy bank while Professor Parker, in answer to Howard's question, gave the following talk on clams:

"In the clams, oysters, and mussels, the shell is composed of two convex pieces, or valves (hence called bivalves), which are generally on each side of the animal and are attached to each other at the dorsal or upper margin by a tough, elastic, horny ligament. In the oysters and some other shells the two valves are not side by side, but are upper and lower; but of these we shall learn more at another time.

"The rounded, raised portion of the shell at the upper part of each valve is called the beak, or umbo (plural umbones), which is marked by

several raised, wavy ridges showing the form of the very young shell. The shell grows by the addition of new shelly matter, and each time new material is added a distinct line is left on the shell. These we call lines of growth. At intervals, a more distinct line edged with black is formed, which shows where the animal rested and stopped work on its shell. These are called rest periods, and by their aid we are enabled to tell the age of a clam. For example, the shell we are studying is five years old, as there are five of these rest periods, counting the last.

"If the shell of the clam is held in the hand with the umbones uppermost and the long end nearest the observer, the right and left sides of the clam are in their natural position and the point nearest the observer is the posterior end, the point farthest away is the anterior end, while the upper, or rounded part, is the dorsal margin, and the sharp, lower part is the ventral margin. The ligament and umbones are also in the center of the shell.



Fresh-water clam, showing interior of shell. A, anterior end; P, posterior end; a, anterior adductor muscle scar; b, posterior adductor muscle scar; c, anterior foot retractor muscle scar; e, posterior foot retractor muscle scar; ct, cardinal teeth; lt, lateral teeth; l, ligament; lu, lunule; pl, pallial line; u, umbo.

"The shell of the clam, as well as those of nearly all mollusks, is covered by a layer of animal matter called the epidermis. This protects the more limy part of the shell, which is composed of carbonate of lime with a little animal matter, from being acted upon by the carbonic acid in the water. This epidermis, or skin, is formed by the edge of the soft part of the animal, called the mantle, which lines the shell If a break occurs in the edge of the shell, it is perfectly repaired by the animal and covered by the epidermis; if, however, the break occurs in any other part of the shell, the damage is repaired by the addition of new shelly matter, but without the epidermis. This shows conclusively which part of the animal secreted this covering.

"Having studied the outside of the shell," said Professor Parker, "let us examine the inside of this dead clam, from which the animal has been removed by the waves. The inside of the valve is concave, and is marked by several very distinct characters. Near the dorsal margin there are two long, thin teeth, or ridges, called the lateral teeth, and two short, conical tubercles just in front of the umbo, called the cardinal teeth. These interlock with similar processes in the opposite valve.

"At either end of the shell, just below the termination of the lateral and cardinal teeth, there is a large, rounded scar which shows where the adductor muscles of the animal are attached, and are therefore called respectively the anterior and posterior adductor muscle scars. Not far from these, two other scars are placed, which show where the anterior and posterior foot retractor muscles are attached.

"The ligament and the adductor muscles are two of the most important factors in the economy of the clam, governing as they do the opening and closing of the shell. The adductor muscles by their contraction serve to keep the two valves closed, while the ligament, which acts as a spring, tends to keep the valves open, the cardinal and lateral teeth guiding the two valves, and keeping them from getting twisted.

"If we were to cut a section through the living animal, we would see that the two shells form a double lever, with the teeth as a fulcrum. The ligament acts upon the short arm of the lever, the umbones, as a spring which is constantly pulling the valves apart. The adductor muscles, on the other hand, act upon the long arms of the lever, and by their contraction pull the valves together. It will readily be seen that when the shell is tightly closed, the animal is not at rest, because this causes some effort on the part of the adductor muscles. The real period of rest is when the shells are slightly gaping, as they are when the animal is partly buried in the mud.

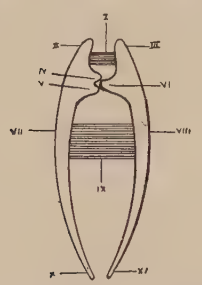


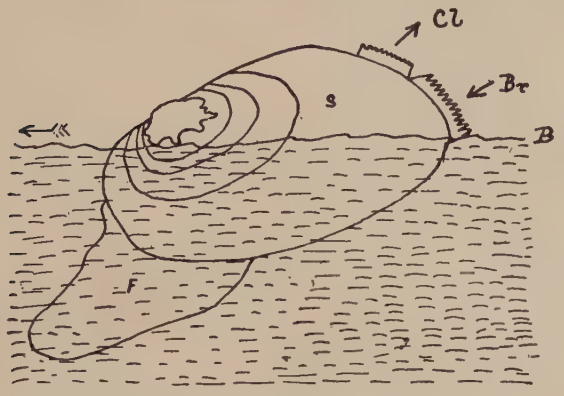
Diagram of a section of clam shell, showing method of opening and closing the valves. I., ligament; II., III., the umbones; IV., V., lateral teeth in the left valve; VI., lateral tooth in the right valve; VII., VIII., left and right valves of shell; IX., adductor muscle; X., XI., ventral surface of shell, or long arms of the lever. (After Lancaster.)

"The hollow in the upper part of the shell formed by the umbo is called the cavity of the beaks: in this are a number of small scars showing where the muscles are attached which hold the animal to the dorsal part of the shell.

"About a quarter of an inch from the edge, an impressed line runs parallel with the ventral margin of the shell. This shows where the mantle of the animal is attached. It is called the pallial line, and extends in an unbroken line from one adductor muscle scar to the other. The interior of the whole shell is pearly and iridescent."

Having completed our examination of the shells, and feeling thoroughly rested, we all followed Harry's example by taking off our shoes and stockings, rolling up our trousers, and wading into the lake after clams. Buried in the muddy sand, they were all about us, and in all conceivable angles. Here and there several individuals were crawling,

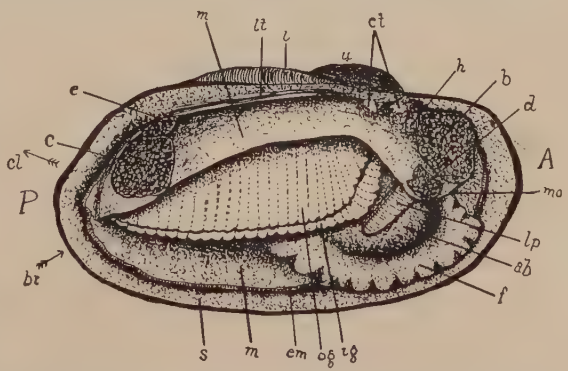
and we paused to watch them. The animal would stretch out its white, fleshy foot to its fullest extent, get a purchase on the sand, and then pull the shell after it, sometimes with a little jerk. In several places the clams had left a well-marked track in the sand, showing the distance which they had traveled.



Fresh-water clam crawling over the muddy bottom of a lake. Cl, cloacal siphon; Br, branchial siphon; F, foot; S, shell; B, surface of mud; <——, direction in which the animal is moving; ↑ ↓, currents of water to and from the gills. (After Morse.)

Professor Parker called our attention to the two siphons which protruded from the posterior end of the shell. The lower one, he told us, was taking in water filled with microscopic plants and animals, which the clam fed upon, and also fresh oxygen for the gills, or breathing organs. The upper siphon at the same time was ejecting the waste products of respiration and digestion.

About noon we stopped collecting and ate our lunch on a grassy slope not far away, after which we proceeded to become better acquainted with these animals. Under the guidance of Professor Parker we removed the right valve of the shell by cutting with a flat-bladed knife through the large adductor muscles, and removing that portion of the mantle which lies next to and secretes the shell, we then beheld the internal organs of the animal. The inside of the shell was lined by the soft mantle, which was the exact form of the shell. Its surface was covered with little cells, which had the power of extracting the carbonate of lime from the blood and building up the shell with it. The shelly skeleton of all clams and snails is formed by a mantle similar to this inside of the shell.



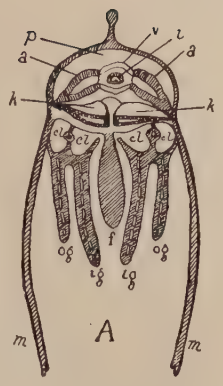
Fresh-water clam with right valve and a part of the mantle removed to show the principal organs of the animal. A, anterior end; P, posterior end; ab, abdomen; b, anterior adductor muscle; br, branchial siphon; c, posterior adductor muscle; cl, cloacal siphon; ct, cardinal teeth; d, anterior foot retractor muscle; e, posterior foot retractor muscle; em, edge of mantle which forms the pallial line; f, foot; h, protractor muscle of foot; ig, inner gill of right side; l, ligament; lp, labial palpi; lt, lateral teeth; m, mantle; mo, mouth; og, outer gill of right side; s, shell; u, umbo.

The fleshy foot was seen to be attached to the abdomen, which was suspended between two pairs of gills, or breathing organs. Each gill was made up of many little leaf-like parts arranged in vertical rows. At the anterior end there were two pairs of organs resembling small gills which were the labial palpi. Between these palpi, or lips, was placed the mouth, a little oval slit. The mantle was seen to be attached to the shell along the pallial line and to be modified at the posterior end by two short siphons, the upper one being separated from the lower by a horizontal partition. The margins of both siphons were lined with short, hair-like organs, called cilia. The upper siphon was seen to be a closed tube on all sides, but the lower siphon was open below, in order that the water entering might bring an abundant food supply in the form of microscopic animals and plants, and bathe the gills, thereby furnishing fresh oxygen for the blood, and pass on to the mouth, which we saw to be placed between the four labial palpi at the anterior end of the body. The water is then taken into the stomach, the small animals digested, and the waste products discharged through the upper siphon.

Professor Parker told us that the clams possess a simple nervous system, which is made up of a ring of nerve matter called the brain. This surrounds the œsophagus, from which branches are sent to the foot, stomach, gills, mantle and other organs. There is an olfactory organ, or nose, and an auditory organ, or ear, the latter situated in the foot. The circulatory system is composed of a heart made up of a ventricle and auricle, from which veins and arteries are sent to the different parts of the body. The digestive system consists of a small, rounded stomach and a long, narrow intestine. "You may be surprised," said Professor Parker, "when I tell you that the clam has no head, although possessing a large mouth which leads directly into the stomach. For this reason the bivalves are sometimes called Acephala, or headless animals.

"If we should make a section of a clam by cutting through the whole animal in the region of the heart, we would find the organs about as I have drawn them in this figure," and he showed us a rough pencil sketch which he had made. "The foot hangs down between two pairs of gills in the lower cavity, or pallial chamber, and the gills are pierced by many little water tubes running longitudinally from one end to the other. In the upper cavity, which is separated from the lower by a partition, are placed the heart, intestines, and kidney. Sections through other parts of the body would appear somewhat different, but this one gives a good general idea of the internal structure, particularly of the two main body cavities."

While Professor Parker had been speaking, Harry, who was the most observing member of the quartette, and who had been carefully examining a clam with one valve removed, exclaimed, "What's this thing in the upper part of the animal which pulsates so regularly?"

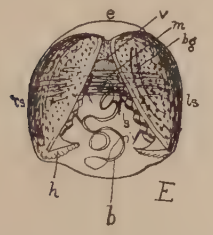


Cross section of fresh-water clam passing through the heart. A, pallial, or branchial chamber; a, auricles; cl, cloacal chambers of gills; f, foot; i, intestine; ig, inner gills; k, kidneys; m, mantle; og, outer gills; p, pericardium, or chamber containing the heart; v, ventricle.

Professor Parker took the specimen and looked at it for a few moments, saying, "This is the clam's beating heart. It is composed of a central ventricle and two lateral auricles which are contained in the pericardium, this being the upper cavity which you saw in my drawing of a section of the clam. There are several large blood-vessels which carry the blood through different sized veins into every part of the body. The throbbings which we see in this specimen are the pulsations of the ventricle pumping the blood into the veins. After flowing through the body and becoming loaded with carbonic acid gas, the blood passes to the gills, where it discharges the poisonous gases into the pallial chambers, absorbs fresh oxygen from the gills, and enters the two auricles, one auricle being placed over each pair of gills, to be again pumped through the body."

Harry was asked to count the pulsations of the heart and he did so, finding sixteen per minute. This was an interesting occupation, and we each counted in turn, finding the records to vary from fourteen to sixteen.

George, who from his habit of asking endless questions had been dubbed the interrogation point, asked how the young clams grew. This question led the Professor to explain to us the wonderful method of growth in the fresh-water clams.



Anterior view of "Glochidium" of Anodonta, inclosed in the eggshell. b, byssus; bg, byssus organ; e, eggshell; h, hooks; ls, left valve of shell; m, posterior adductor muscle; rs, right valve of shell; s, setæ; v, velum. Greatly magnified. (After Brooks.)

"The gills of the fresh-water clams are modified to form marsupia, or pouches, and in these the young clams develop from the egg until they attain a certain size and shape called a glochidium. The shell, mantle, and muscles are developed, but the digestive organs are not formed until six months or a year afterward. The animal is inclosed in a thin eggshell in which are enveloped the embryonic shells of the animal. These are united by a hinge, which is so elastic

that the two valves are frequently seen in the same plane. A long, thread-like organ called a byssus is placed between the valves, and this enables the young clam to anchor itself to a stone when it becomes free. The lower surface of the shell forms two toothed hooks.

"The young of some clams, as *Anodonta*, reach this condition in a few days in the fall, and they remain in this state until the following spring, when the parent discharges them into the water. The embryos now swim about by opening and closing their shells and search for a fish, into the fins or gills of which they drive their hooks and close their shells. The fish covers the glochidium with a layer of living cells and it becomes encysted. Here it develops gills, stomach, intestines, and heart, and finally breaks the cyst or walls of its prison and falls to the bottom of the water, a perfect young shell. From this point its growth consists in simply enlarging its shell."

We had all heard of mammals which carried their young in pouches, like the kangaroo of Australia, and Harry said he had recently read of some sea-urchins living in the Pacific Ocean which also carried their young in marsupia, but that clams should be marsupials was something new to us.

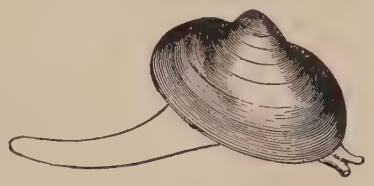
Professor Parker also pointed out the difference between the male and the female shells, the latter having the lower posterior part of the shell much swollen to accommodate the enlarged gills when they are used as marsupia, while the male shell is thin and perfectly even in this part. We also learned that only a few of the fresh-water clams could be thus distinguished, for in a large number the shells of both sexes are alike.

After gathering a number of clams and snails we walked several miles to the shore of Lake M——, where Professor Parker thought we might find some species which did not live in the smaller lakes and ponds. Just as we were leaving the head of Lake C——, Harry discovered a pile of clams on the shore, from which the animals had been neatly extracted, leaving the shells as perfect as any collector could wish. The Professor told us that this was the work of the muskrat, that animal being very fond of fresh-water clams. "The vicinity of its burrows," he said, "are always good places in which to find perfect and clean specimens of many comparatively rare species."

When about half the distance to the lake had been covered, we came to a small ditch. The Professor remarked that this ought to be a good place for the small clams of the genera *Sphærium* and *Calyculina*, and so it proved upon examination. The muddy bottom seemed fairly alive with their delicate, horn-colored shells, which were from a quarter

to a half inch in length. The Professor told us that these small clams live plentifully in pools, ponds, ditches, and streams.

In about an hour we reached Lake M——, and walked along the shore for some distance in search of molluscan life, but met with little success as far as living species were concerned. In the line of debris which had been thrown up by the waves, we found a large number of very small snails and clams and a host of insects belonging to the beetle order. George managed to find several large clams like those which were so plentiful in Lake C——, but with very much heavier shells. We asked Professor Parker if they belonged to the same species and he said they did. He told us that the reason they were so heavy was because the waters of a large lake like Lake M—— were very rough, and that the shells were subject to a great deal of rolling about, while the waters of the smaller lakes were comparatively calm, and the shells, being allowed to remain quiet, were consequently more delicate. We also learned that the *Anodontas*, which have thin shells, are generally found in still bodies of water on muddy bottoms, while the *Unios*, which have very thick, solid shells, prefer, as a rule, the bed of running streams.



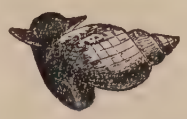
Calyculina transversa, with its long, narrow foot and two short siphons extended. (Prime's Monograph.)

We reached home late that night, footsore and weary and desperately hungry, but with our bottles, pockets, and baskets filled with shells, and our minds fresh with the memory of a joyful day spent in communion with Mother Nature.

COLLECTING ON THE SHORE OF A LAKE

Photograph by Dr. Alja R. Crook

A DAY WITH THE POND SNAILS

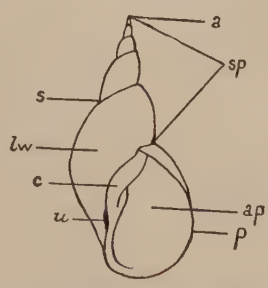


Limnæa desidiosa, a small pond snail. (Binney.)

A few days after the collecting trip recorded in the preceding chapter, Professor Parker and our quartette of young naturalists again visited the country in search of fresh-water snails.

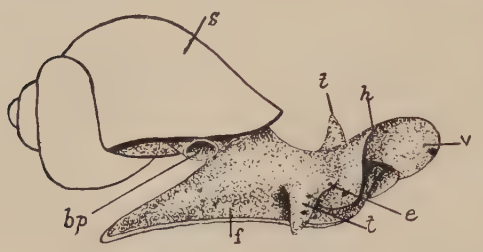
This time a different direction was taken, and a locality visited which was not at such a great distance from the city. This was reached by an electric-car ride of half an hour. It was a beautiful spot. A creek wended its way through a small ravine, which was overhung by tall, majestic trees. The banks were grassy and bordered by sedges, willows, and various shrubs. The little creek ran merrily along, now dancing over a pebbly bottom and again flowing sluggishly between steep banks, until it joined its waters with those of a large river. Here was one of Dame Nature's choicest retreats, and we proposed to wrest some of her secrets from her.

After leaving the car, a walk of ten minutes brought us to the river, which Professor Parker desired us to examine before going to the creek. Harry was so anxious to secure the first specimen that he rushed on ahead and stooped over the bank, earnestly peering into the water. Suddenly, with a cry of exultation, he held up to view several large specimens. A nearer approach showed them to be living specimens of the large pond snail, *Limnæa stagnalis*, and all hastened to examine the animals. Professor Parker took a specimen in his hand and showed us the principal characteristics of the mollusk. The shell of this snail was long and graceful and of a rich horn color. The spire was very much elevated and tapered to a point; the whorls were much longer than wide, and separated by a distinct suture. The aperture was wide and very large, and the peristome, or outer lip, was thin and sharp, like that of most fresh-water shells. The columella, which means little column, was covered with a deposit of shelly matter, and the umbilicus was indicated by a little chink, or fissure.



Pond snail, showing different parts of shell. a, apex; sp, spire; s, suture; ap, aperture; p, peristome; c, columella; lw, last whorl; u, umbilical region.

While we were examining one of these shells, the occupant thereof was twisting itself about in a vain effort to find some object upon which it might crawl. This gave us a splendid opportunity to examine the animal. Its color was dark horn, with a bluish tinge on the head. The foot was very broad and flat, and separated from the head by a little constriction. The head was very broad, and widened at the sides into two lobes, called vela. The tentacles were short and triangular, and on swellings at their inner base the little black eyes were placed. Just at the edge of the shell, the little hole through which air enters the lung could be seen opening and closing.



Animal of pond snail (Limnæa mighelsi). bp, breathing pore; e, eye; f, foot; h, head; s, shell; t, tentacles; v, vela, or lateral lobes of head.

"We must understand," said the Professor, "that the snail cannot leave his house or shell any more than the turtle can crawl out of its shell. The animal of the pond snail is fastened to the columella by a huge columella muscle, which grasps this part of the shell and holds it fast. A part of the animal, called the mantle, is kept in close contact with the shell by means of small muscles called sphincter muscles. It is the edge of this mantle, called the mantle collar, which secretes the shelly matter and builds up the shell. It also provides the beautiful colors seen in shells which are found in the tropics. We must thoroughly understand that were we to take the animal from its shell, it would die.

"The animal, when removed from the shell, is seen to be the exact counterpart of it, and it is also seen to be covered with a soft membrane, the mantle, which is molded to the shell. The spire is mainly occupied by the enormous liver.

"You will remember," continued the Professor, "that we spoke of the clams as bivalves because they had two shells. The snails are called univalves because they have but one valve, or shell, which is generally in the form of a spiral, as you have already learned. All snails are not univalves, however, as you may observe when you visit the museum. Some snails have the shell composed of several pieces, while other snails are without a shell."

Placing the pond snails in our collecting pail, we then looked for other molluscan inhabitants of the river. Just a little way from the shore, several large pond snails could be seen apparently crawling on

the surface of the water, with little wave-like motions passing over it, with shell downward and spreading foot turned upward. The snails had also extended their breathing orifices to the surface of the water in the form of tubes or siphons. Professor Parker remarked that the animals were busily engaged in taking in a supply of fresh air. He said that pond snails, orb snails, and some other mollusks breathe air by means of a lung in the same manner as the land snails, and they are compelled to come to the surface at intervals for the purpose of exhaling the poisoned air and taking in a supply of pure air.

A short distance from the place where the *Limnæas* were found, were noticed a number of snails in the water, gliding along, with a peculiar wheel-like shell set edgewise on their backs. These were the *Planorbes*, or orb shells. The animal was much like that of the pond snail, except that the tentacles were very long and thin, instead of being flat and triangular. The shell was tightly wound like a watch-spring, and the upper and lower surfaces, that is, the spire and umbilicus, were in the same plane, and the full number of whorls (four) could be plainly seen. The aperture was rounded and the outer lip thin and sharp.

Orb snail, Planorbis; shell with animal creeping over the ground. (Binney.)

Crossing over a little neck of land which extended into the water, our party reached the small creek which flowed into the river in which lived a great number of pond snails, orb snails, and another variety very numerous in specimens which were gliding swiftly about as though bent upon important business. "These," Professor Parker said, "are the *Physas*."

As these were fine, large specimens, we all stopped to gather a number for our collections. The shells of these snails were about three-quarters of an inch in length, highly polished, and with a short spire and very large aperture. But the aperture of the *Physa* seemed different from that of the pond snail. Upon comparing the two shells, the *Physas* were found to have the aperture on the left side, while the pond snails had it on the right side. Professor Parker explained that these two snails were typical of all gastropod shells. In the great majority of snails the aperture is on the right side, and these are called dextral or right-handed shells. In a few, like *Physa*, the aperture is always on the left side,

Left-handed or sinistral pond snails, Physa gyrina.

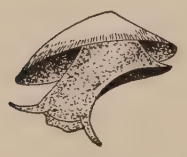
and these shells are called sinistral or left-handed shells. Some shells, as a variety of the apple snail, *Campeloma decisum*, may be either dextral or sinistral, but only a few species of snails are both right and left handed.

The animal of the *Physa* seemed similar to that of the orb shell, the tentacles being long and slender, and George asked if there was any difference. The Professor suggested that we examine a specimen carefully. This we did, and found that it differed from all the other fresh-water snails in having many little finger-like projections on the edge of that part of the mantle covering the columella. These were arranged in two series of rows, one near the lower part of the columella and one near the point of juncture of the outer lip with the body whorl. The whole animal was yellowish gray or blackish in color, flecked with yellowish white, the spots being plainly seen through the transparent shell.

Animal of Physa. (Binney.)

Professor Parker then told us that *Physa* was one of the hardiest of snails, and that he had frequently seen it in winter gliding over the bottom of a pond or creek when the surface was covered with ice. The shells, he said, were very variable, scarcely two specimens being exactly alike.

A short distance from the shore of the creek were a number of dead clam shells, and George fished up several of them with the wire net. One of these shells had several little snails upon it which were quite new to us. These snails were flat and limpet-shaped, and about a quarter of an inch in length. The animals looked like *Limnæa*, with their flat, triangular tentacles and broad foot. The Professor said that these curious little fresh-water limpets, *Ancylus*, were very common on both the outside and inside of clam shells, and on stones, sticks, and other submerged objects.



Ancylus rivularis. River limpet, with animal extended. (Binney.)

Having exhausted this part of the creek as a collecting locality, a shady spot was selected in which to eat lunch, and never was feast more enjoyed than was that simple lunch, the appetites being whetted to the keenest edge by the fresh air and vigorous exercise.

After lunch, our party walked across several fields, passed through a patch of woods, and crossed a stretch of swamp, where Howard fell into a hole, thereby scaring several water fowl. Finally we reached the shore of a large lake, where Professor Parker said another type of mollusk was abundant.

Leading the way to a little point of land which extended into the lake, he bade all take off shoes and stockings, roll up trousers, and wade into the water in search of snails. Harry as usual was the fortunate one, and soon came across a colony of long, slender shells. "They are a species of the water-breathers," said the Professor, "which are called *Pleurocera elevatum*. They are named water-breathers because the oxygen is supplied to the blood by means of a gill instead of a lung, as in the snails which have been previously seen. This snail," he added, "like others of its family, does not like a muddy bottom, but prefers a rocky or sandy bed, in which it delights to partly bury itself. It is seldom found in a muddy pond or stream."

Shell of Pleurocera elevatum, a water-breather. (Tryon.)

The animal had a short, thick, wide foot, and its color was blackish or yellowish in a more or less mottled pattern. The head ended in a rather long rostrum, or snout, which was yellowish with a black patch on top, and the mouth was placed at the extreme tip. The tentacles were long and tapering, and the black eyes were placed on little prominences at the bases of the tentacles. The upper part of the hinder end of the foot supported a horny, ovate operculum, which closed the aperture when the animal withdrew into the shell.

Professor Parker explained that in the water-breathers, including the fresh-water and marine mollusks, the proboscis is of two kinds: in one, it is simply contractile—that is, it can be contracted as when one presses a cushion spring together—while in the second class, it is retractile, and can be retracted like the eye-peduncle of a land snail. The genus *Pleurocera* is a good example of the first class, and the *Dolium*, or tun-shell, of the second class.

This small snail differed from the ones which had been previously collected not only in breathing by gills instead of by lungs, but also in having an operculum, and in having the mouth placed at the end of a snout. "These differences," Professor Parker remarked, "are characteristic of most fresh-water snails."

On one side of the miniature peninsula were a number of rounded objects half buried in sand, and of a rich green color. Upon investigation they proved to be a species of the apple snail, *Campeloma decisum*. The shell of this snail was of a beautiful apple-green, the whorls were gracefully rounded,

Shell and operculum of apple snail, Campeloma decisum. (Binney.)

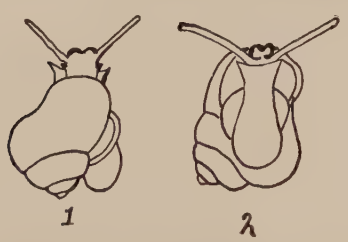
and the whole shell was solid and heavy. The aperture was tightly closed by the operculum.

While Harry was holding the shell in his hand, the animal came forth and stretched itself out to its fullest extent. Attention was immediately attracted to the enormously wide, thin foot, which seemed to envelop the rest of the animal in its ample folds. The tentacles and snout were short, and the eyes were placed near the base of the tentacles, on the outside, where they were much thickened. The operculum was attached to the back of the foot, and was oval in shape, being made up of many concentric rings; it was also tough and horny.

Animal of Campeloma, showing its large foot, its tapering tentacles, and the rounded rostrum, or proboscis, between them. (Binney.)

Having collected a number of the apple snails, besides some others, our party walked to another part of the lake, where the bottom was muddy, and where the water contained some water-plants. Here the wire scoop came into play. The first haul produced nothing but a few pebbles and a lot of mud. Fearing that the handle was not long enough, all of the joints were attached and we tried again. This time it was not in vain, for the scoop came up filled with soft mud, which was literally loaded with the shells of a small snail, *Amnicola limosa*, and with several varieties of the little clams like those which were collected on the previous trip.

The snails were placed in a bottle of water, and soon came out, and began to crawl up the sides of the glass. With their small foot, long cylindrical tentacles, globular shell, and large operculum, they were very interesting specimens. Professor Parker selected a number of these, and also several of the apple snails and the *Pleurocera*, and placed them in his pail, to be added to those already in his aquarium at home.

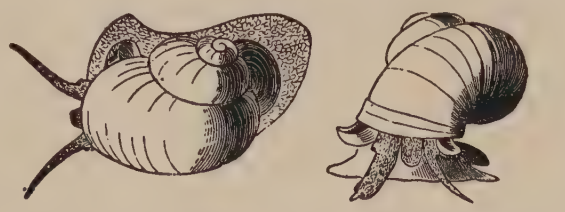


Dorsal and ventral views of animal and shell of Amnicola limosa. Magnified. (Stimpson.)

Among the apple snails collected were several which had the spire of the shell broken off, and George asked how this was done. The Professor replied that in many of the shells the end of the spire frequently became empty, as the animal built the shell near the aperture. As the dead tip soon became brittle, it broke off, and the animal built a partition across the exposed part of the whorls. The shells in this condition are called decollated. In some small marine shells, called *Cœcum*, the decollation takes place to such a degree that when the animal is adult, the shell

is simply a straight tube. In the young animal, the shell is spiral. Some land shells, called *Cylindrella*, have been seen to voluntarily break off the dead apex by hitting it against a stone.

As it was now getting late, the collecting outfits were packed, and we started to walk to the car line, which was about a mile distant. On the way, we passed a small stream on one side of the road which was literally filled with decaying vegetable matter, and across from it on the other side of the road was a small pond fairly black with fine, impalpable mud held in suspension in the water. George began to examine these places in the hope of finding a few more snails, but he was told by the Professor that mollusks could not and would not inhabit water in such a condition. In the case of the first stream, the decaying vegetation caused the presence of carbonic acid gas, which was inimical to the life of the snail; and in the pond, the fine mud interfered with the breathing of the mollusks. It was also learned that a stream with a very rapid current and a bottom composed of crystalline gravel was not well adapted to the life of fresh-water snails. Such snails as *Physa*, pond snails, and apple snails love a still pond or sluggish stream, in which the bottom is more or less muddy.



Apple snail, Vivipara intertexta. Animal and shell viewed from above and in front. Left figure, female; right figure, male. (Binney.)

On our way home in the cars, we amateur conchologists plied Professor Parker with questions about fresh-water snails. Observing that we were thoroughly interested, he suggested that we visit the museum with him the following Saturday, and study the different types of this class of mollusks. To this, all gladly assented.

SNAILS OF POND, RIVER, AND BROOK

On the Saturday following the trip to the river and creek, the large museum in the park was visited, and under the guidance of Professor Parker we studied the shell collection, and particularly the specimens from fresh-water streams and ponds. The Professor was thoroughly acquainted with this class of animals, and narrated many interesting facts as we went from case to case.

"Our fresh-water snails," he said, "may be divided into two classes: first, those which breathe by means of a lung and which must come to the surface at regular intervals to take in a supply of air; and second, those which breathe by means of plume-like gills, which take the oxygen directly from the water.

"One of the most common and best known of the first class is the *Limnœidæ*, comprising the pond snails. These animals generally have a long, graceful shell, horn-colored for the most part, but sometimes greenish without and reddish within the aperture. They have a broad, flat foot; an auriculate, or eared, head; and flat, triangular tentacles.

"It is interesting to note that the young animals breathe air through the water for a long time, but finally acquire the normal characteristic of the family, which is, breathing the air directly. While submerged, the mantle chamber containing the lung is tightly closed, so that no water can possibly enter. It is thought by some that the species of *Limnœa*, living at great depths in large lakes, retain the early habit of allowing the water to fill the mantle cavity and so breathe oxygen through the water. They are not therefore compelled to come to the surface for air.

"*Limnœas* live under many varying conditions, being found in the arctic regions of Greenland and Iceland as well as in the tropics, in thermal springs, and those containing sulphur and other mineral matter as well as in brackish and in fresh water. In Thibet, they have been found at a height of over fourteen thousand feet, and in Lake Geneva, Switzerland, at a depth of eight hundred feet.

"During times of drought, when streams are dried up and the surface of the mud is sun-cracked, the species of the family bury themselves deeply in the mud and cover the aperture with an epiphragm

FROM COL. CHI. ACAD. SCIENCES.

COPYRIGHT 1901, BY A. W. MUMFORD, CHICAGO.

POND SNAILS AND RIVER SNAILS.

Physa gyrina (U. S.)

Pleurocera elevatum (U. S.)
Vivipara contectoides (U. S.)

Melania tetrica (Viti Islands.)
Planorbis trivolvis (U. S.)
Ampullaria depressa (U. S.)
Campeloma subsolidum (U. S.)

Angitrema verrucosa (U. S.)

Limnaea stagnalis (U. S.)
Limnaea megasoma (U. S.)

in much the same manner as is done by the land shells. This fact accounts for the apparent disappearance of all life from a pond when it dries up, and its sudden and seemingly unaccountable reappearance when the pond is again filled with water.

"Next to the *Limnæas*, the *Planorbes*, or orb-shells, are the most abundant and interesting, although not exhibiting a large amount of variation, as you will see by the specimens in this case. Their rounded, orb-like shells are found along the shore of almost any pond or stream. In size the shells vary from the little *Planorbis parvus*, so common among the fresh-water algæ and which is scarcely an eighth of an inch in length, to the giant *Planorbis corneus* of Europe, with a shell over an inch in diameter. The *Planorbes* are found in nearly all parts of the world.

"The family *Physidæ*, containing left-handed or sinistral shells, is one of the most distinct of all the fresh-water mollusks, not only in the form of the shell, but also in the character of the animal, the mantle being ornamented by many little finger-like projections which are reflected over the inner lip of the shell. We learned something about these animals on our last collecting trip; how they move over the bottom of a pond or creek with a steady, gliding motion, even when the surface of the water may be frozen. The shells are almost always smooth and glossy, and average from half an inch to an inch in length. Like the *Limnæas* and *Planorbes* they are found in many parts of the world. The egg-masses of *Physa*, *Planorbis*, and *Limnæa* (little, glairy, transparent, jelly-like objects) may be seen in the spring in almost any pond or stream, attached to sticks, stones, or the under side of water-plants.

"Not all of the fresh-water pulmonates have spiral shells. A whole family, the *Ancylidæ*, have a conical shell formed like a rounded shield and resembling the limpet of the seashore; hence they are called river limpets. They are generally quite small, some of the species being less than a quarter of an inch in length. They live attached to the interior of dead river shells, and to submerged plants and rocks. They are very interesting, but hard to find on account of their small size and inconspicuous habitat.

"The second class of mollusks of which I spoke a short time ago (those which breathe air through the water) have a respiratory cavity instead of a lung, in which is placed a series of leaflets arranged like the teeth of a comb in two series of lines, forming the so-called gills. The mouth is placed at the end of a long rostrum or proboscis and not in the lower plane of the head, as in the last class. We must

cross the museum to study these snails, as they belong to a different order from the air-breathers."

In a few moments, we had walked to the opposite side of the museum and had gathered around the case which the Professor had pointed out to us. All became silent and eagerly listened, while the Professor continued:

"Among the most common of this order are the river snails known as *Strepomatids*. There are about three hundred species in this family, and with two or three exceptions they are confined in geographical distribution exclusively to the United States. The shells are very graceful, having long, turreted spires of ten or twelve whorls, and small apertures. The color of the shells is generally a uniform greenish or yellowish, although some species have color bands, and the aperture is frequently tinged with purple or red. It is an interesting fact that the majority of the species of this family are found in the rivers and streams of Tennessee, Alabama, Ohio, West Virginia, and Mississippi. From these states a few species have migrated to the east, west, and north, and are now found in almost every part of the United States. You will see by the number of shells exhibited in this case what a variety of species occur in this family.

"A family closely allied to the last is the *Melaniidæ*, the animals of which inhabit the entire world, except North America. They may be distinguished from the last family by the presence of little finger-like digitations on the edge of the mantle, similar to those in *Physa*. The shells are generally larger and more highly colored than those of the *Strepomatids*, many of them being of a dark chocolate color, while some are a beautiful glossy black; some shells are smooth, while others are ornamented by knobs and spines. The genus *Melania* is the most characteristic form. Some species are viviparous, like the apple-snails.

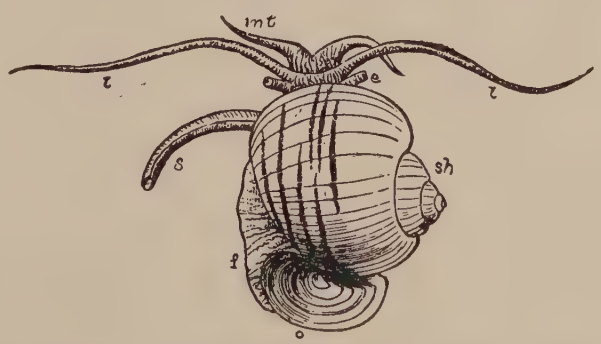
"The largest and handsomest of the fresh-water snails belong to the two families, *Viviparidæ* and *Ampullariidæ*, the shells of the latter family frequently attaining a length of three inches. The animals of the first family prefer a sandy beach in a large lake or river, while those of the second generally live in more or less muddy rivers, ponds, and creeks. A single genus of *Viviparidæ*, *Campeloma*, is confined solely to that portion of the United States east of the Rocky Mountains. The shells are generally of a rich grass-green, and in certain localities they may be collected by thousands.

"Unlike many of the snails at which we have been looking, this family is viviparous; that is, it brings forth its young alive instead

of laying eggs, as do the family *Limnæidæ*. This characteristic has given the family its name, which is certainly well chosen. When born, the shell is generally about one-sixteenth of an inch in length, and is perfectly transparent. The animal is very active and eats voraciously of any vegetation within reach. One of the handsomest shells of this family is the *Vivipara contectoides*, which is about an inch in length, and is encircled by several color bands. It is a common shell in many of our ponds.

"Somewhat larger and more showy than the *Viviparas*, are the *Ampullarias*, or apple-shells, also called idol-shells and pond snails. These animals live chiefly in tropical and subtropical regions, and are noted for the tenacity with which they retain their hold on life. So tenacious of life are they that instances are known of their living for several years away from the water; in this respect they resemble some of the land snails. It is also recorded that hollow pieces of logwood from Honduras have frequently contained specimens of this family, which were alive after a journey of thousands of miles. They may be said to be truly amphibious.

"One species of this family, *Ampullaria depressa* (of which you may see a fine set of specimens in this case), is very common in Florida, where it forms a large part of the diet of the everglade kite, a bird inhabiting the southern part of the state. Large quantities of these shells, from which the animal has been neatly extracted without in the least damaging the shell, may be found about the nesting-places of these birds. The kite is, curiously enough, provided with a curved bill which easily fits into the aperture of the mollusk and extracts the animal with little difficulty. The feet and claws are so constructed that the shell may be firmly held during the operation.



Animal of Ampullaria depressa, with its siphon and tentacles fully extended. e, eye; f, foot; mt, mouth tentacles; o, operculum; s, siphon; sh, shell; t, tentacles. (Tryon.)

"The animal of *Ampullaria depressa* is very curious and interesting when studied alive. The foot is very wide, almost square in some positions; the head is narrow, separated from the body by a neck; and the region of the mouth is produced into two long, cylindrical, tapering tentacles, which are probably tactile organs, like the elongated lips of the land

snail *Glandina*. On the top of the head, the two whip-like tentacles are placed. These have a greater length than that of the whole animal, and are always waving about when the animal is in motion. Just back of the tentacles, the eyes are found at the end of two short, rounded prominences, or peduncles. From the left edge of the aperture, the long, hollow, cylindrical siphon protrudes. This is formed by two extensions of the mantle. On the upper side of the posterior end of the foot, the horny, concentric operculum is placed. When the animal withdraws into its shell, the head first disappears with its appendages and the siphon, then the foot is doubled up in the middle, the operculum shutting in last and closing the interior against all enemies.

"In the farther end of this case you will notice a set of very peculiar shells, some of them looking like marine shells, yet living in fresh water. They live in Lake Tanganyika, a body of water situated in Central Africa, and having a length of four hundred miles and a width of from ten to fifty miles. This lake has an elevation of twenty-seven hundred feet above sea level, and possesses one of the most interesting and peculiar fresh-water molluscan faunas known. It is thought that in some remote period in geological history it formed part of the ocean, and that in the course of time it was cut off from the sea, gradually becoming fresh, and was finally raised to its present elevation. The reason for such a theory is the presence in the lake of certain molluscan organisms whose shells closely resemble those of the fresh-water family *Littorinidæ*, or periwinkles. The fact that certain species of this family inhabit brackish water, and are even subject to the influence of fresh water, gives additional weight to this theory. The shells of one species, *Limnotrochus thomasi*, from Lake Tanganyika, also resemble certain of the top shells (*Trochus*) which are marine in habitat. Most of the species living in this lake are like the *Viviparas* in form.

Limnotrochus thomasi, from Lake Tanganyika. (Tryon.)

"All of the different groups of the Mollusca have their giants and their pigmies, and the fresh-water mollusks are no exception to the rule. We have, as yet, only studied the animals of normal size, and the giants. Let us now turn our attention to some of the pigmies of these snails.

"One of the commonest of these small mollusks is the *Bythinia tentaculata*, the shell of which does not exceed half an inch in length, and having the form of a graceful, tapering turret. This species, like many other European animals, has been introduced into America, and bids fair to eclipse many of the native species in the number of individuals.

It probably first came over with some merchandise which was shipped west by the Erie Canal. The snail, once established in the canal, has had every opportunity to spread over the entire United States. The canal is emptied every year and cleaned, and the water with its organisms is allowed to flow into the little streams and the larger rivers and thence into Lake Ontario. From this lake, the species has spread so that it is now found in Lakes Erie and Michigan, and it will eventually spread over the entire northern portion of the United States. This is but one of the many examples of different species being carried by human agencies from one part of the world to another.

"But there are many species of these smaller fresh-water snails that are pigmies indeed, whose tiny shells do not exceed an eighth of an inch in length, and which require the aid of a microscope to adequately study their delicate organism. These minute organisms live on water-plants and on any submerged object. They vary from long, pointed, steeple-like shells to those which are perfectly round, like a miniature apple. These little creatures are found in all parts of the world, and in our own country they may be found in any of our ponds and streams. The lively little animals are well worth a closer acquaintance. They are known scientifically under the rather difficult names of *Paludinella*, *Amnicola*, *Somatogyrus*, *Fluminicola*, *Pomatiopsis*, and many others, and do not have any specific English titles.

Pomatiopsis lapidaria, a minute fresh-water snail. Animal and shell enlarged. (Binney.)

"There is another group of mollusks which is intermediate between the land shells and the fresh-water shells," continued the Professor, "and you will observe several good specimens in this case. One of these belongs to the family *Amphibolidæ* and has a spiral shell. It inhabits the seashore salt marshes of New Zealand, where it lives in pools of brackish water. During dry periods it buries itself in the sandy mud. The aperture of this shell is closed by an operculum, and the branchial cavity communicates with the air by a valvular opening. It is said to be esteemed by the natives of New Zealand, as an article of food.

"Another example of this curious group is the *Siphonaria*, which lives on the seashore, between tides. The shell is flat like that of the limpet, and the single genus *Siphonaria* is found in most parts of the world."

Having spent nearly the whole afternoon in the museum, we returned home, filled with enthusiasm, and each one determined to acquire a large and fine collection of shells.

WHERE POND SNAILS DELIGHT TO DWELL

Photograph by T. H. Purple

IN THE HOME OF THE SNAIL

Among the beautiful pictures
That hang on memory's wall,
Is one of a dim old forest,
That seemeth best of all.

— Alice Cary.

Several weeks after our visit to the museum, Professor Parker invited us to go with him to the woods on a collecting trip after land snails. Accordingly one bright morning our quartette, with the Professor, boarded the street car; and after a ride of half an hour we reached the country, ready for work. The piece of woodland in which the Professor wished to make the collections was about a mile from the car lines, and toward this we wended our way.

Polygyra palliata. A common land snail. (Binney.)

It was a beautiful day; the air was cool and the sun shone brightly, although not too warmly, and everything about us looked fresh and green after the warm rain of the previous day. The country road was sandy and bordered on either side by a small ditch, through which was flowing a stream of clear water from a nearby spring. At the left, a field of grain was ripening in the sun, the breeze making long billows over its even surface. On the opposite side, the cattle were grazing in a pasture bordered by a hedge of low shrubs.

Jumping over the fence which inclosed the pasture, and crossing the field, we were soon in the woods busily searching for its molluscan inhabitants.

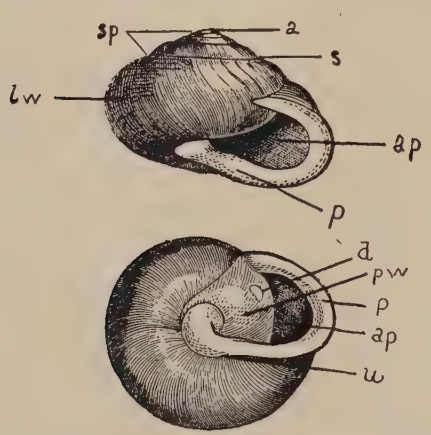
Each one carried a collecting outfit, consisting of a tin mustard box, a couple of wide-mouthed two-ounce bottles, and several homœopathic vials, the corks of which were tied to the neck of the bottle by a stout thread to insure us against their loss in the underbrush. The bottoms of the tin boxes and of the large bottles were lined with cotton to prevent the thin shells of some of the snails from being broken. For scratching away the dead leaves, under which many species of mollusks are found, each had a small hand rake with a short

5122

handle which could be removed to enable the whole apparatus to fit in the pocket. For picking up the very small shells, we had provided ourselves with a pair of very slender tweezers. A good-sized pocket-knife and a small trowel, completed the outfit.

After walking into the forest a short distance, we came to an open spot where the ground was covered with a rich loam. The mass of dead leaves was several inches in thickness and formed a soft bed on the ground. There were also many old rotting trunks of trees scattered about. Here, indeed, was an excellent locality for a conchologist. Harry discovered the huge prostrate trunk of a tree before he had gone many rods, and Professor Parker said that it ought to be a good habitat for some of the larger snails. Judging by its moss-covered surface and rotten condition, it must have lain in its present position for some time. We all put our shoulders to the fallen trunk, and succeeded, after several ineffectual efforts, in turning it over.

The surface of the ground exposed by the overturned trunk was fairly alive with animate creatures. Here was a reddish centipede about two inches long, just disappearing down a convenient hole; there, in a little hollow formed by some decaying leaves, was a thousand-leg, or millipede, and all over both ground and trunk were black, green, and red beetles, and black ants: but best of all, closely attached to the under side of the trunk, were several fine, large specimens of the white-lipped snail, *Polygyra albolabris*.



White-lipped snail, showing parts of shell. a, apex; ap, aperture; d, denticle; lw, last whorl; p, peristome; pw, parietal wall; s, suture; sp, spire; u, umbilicus. (Binney.)

Professor Parker picked up one of the snails (the animal of which quickly disappeared within its shell) and explained to us its different parts and characteristics, and showed us how it differed from the fresh-water snails. The shell was somewhat top-shaped, and composed of five or six whorls or turns which were closely and evenly coiled about the axis. The spire was not elevated as in the pond snails, but was very much depressed and dome-shaped; the apex was small, and light horn-colored, and the sutures separating the whorls were very distinct. The last or body whorl was very large and swollen.

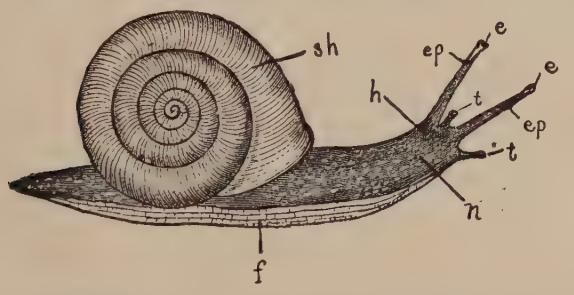
The aperture, within which the animal had just disappeared, was large and shaped somewhat like a half-moon. The outer lip of the

snail's shell was turned over or reflected, forming the peristome, and was not thin and sharp, as was that of the pond snail. Professor Parker said that in some land shells the lip was thin and sharp, without a reflected peristome. We also noticed the white deposit of shelly matter which covered the umbilicus. The Professor told us that this showed that the snail was fully grown, as in the young snail the umbilicus was very wide and deep. In some land snails, he said, the umbilicus is always open, even in adult life. On the inner lip, or parietal wall, we noticed a small denticle, or tooth; and on the outside, we observed the fine, regular lines of growth.

Limax agrestis, a snail without an external shell. (Binney.)

Professor Parker remarked that, as in the fresh-water snail, the shell of the land snail was inseparably attached to the animal. But just as he spoke several peculiar animals crawled along the log which we had overturned, looking exactly like the snail without its house, and George at once said, "Why, what are these? Have they not lost their shells?" The Professor replied that these were garden slugs, which were snails that had no shell, but in its place, a tiny shelly plate situated on the back to protect the lung, and covered by a part of the mantle.

He then suggested that we watch the white-lipped snail and see if it would crawl about. Soon we saw a slight movement, then the large, fleshy foot appeared, and then the head was cautiously thrust out. A moment of hesitation followed, the tentacles and the rest of the head appeared, and the animal stretched out and began to crawl over the log, carrying the shell as shown in the accompanying figure. As the animal crawled along, it left a glistening track of mucus behind it.



White-lipped snail, showing parts of animal. e, eye; ep, eye-peduncles; f, foot; h, head; n, neck; sh, part of shell occupied by lung; t, tentacles. (Binney.)

From the head, two long tentacles extended which pointed straight ahead. They moved about restlessly, touching every object which came in the path of the animal, and retracting suddenly if any obstruction was met. These were the eye peduncles, and by looking very closely, we could see the little black eyes at their tips.

Harry gently touched one of the eyes with his finger to see what would happen. It at once disappeared. Professor Parker asked us

to observe closely the snail's method of drawing the eye peduncle into the body. After remaining retracted for a few seconds, the peduncle was again stretched out. This time we watched intently as Harry lightly tapped the eye. As it retracted, we saw the black eye run down the interior of the peduncle and disappear in the head. Howard, who was nearest the animal, suddenly exclaimed, "Why, that is exactly the way my sister pulls off the fingers of her kid gloves." The Professor smilingly remarked that that was exactly the point he wished us to see, for the eye peduncle is retracted in just the same manner as the finger of a kid glove is turned inside out. He told us that a set of muscles is attached to the inside of the peduncle at the tip, and when the eye is touched, the muscles contract and draw the whole peduncle into the head, outside in.

Just beneath the eye peduncles, we noticed two short, finger-like organs. These were the true tentacles, with which the animal feels about. The back of the animal was covered with many rounded tubercles, and the center of the tail, or posterior part, had a prominent ridge, or keel.

Harry now picked up the animal by its shell, and we examined the under surface of its long, wide foot. At first, the animal contracted a little into its shell, but soon it stretched out again to its fullest extent, and twisted itself about from side to side, raised its head and thrust its eye peduncles about in every direction in a vain endeavor to find some solid support. George inquired what it was that resembled water and seemed to be flowing over the bottom of the snail's foot. Professor Parker replied that it was the contraction and expansion of the muscles on the under surface of the foot which gave this wavy appearance. "The glistening effect," he said, "is caused by the mucus which is constantly flowing from the foot. If we place a snail on a piece of glass, these wave-like movements may be seen to cause the animal to glide over the surface."

As we were looking at the foot, we noticed a hole of good size which opened and closed at regular intervals, in that part of the animal remaining in the shell. This, Professor Parker said, was the opening into the lung which allowed the fresh air to come in and the impure air to escape. He also reminded us that land snails breathe by means of a true lung, which occupies the last whorl of the shell. "This lung," he said, "is composed of a network of blood-vessels, through which the blood flows after it has passed through the body and is filled with carbonic acid gas. The foul air is expelled and the fresh air enters and purifies the blood, which flows to the heart to be again pumped through the body."

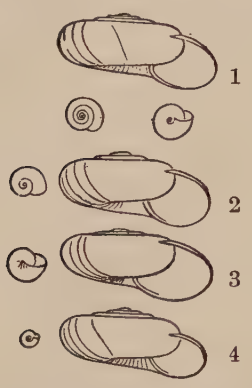
The prolonged examination alarmed the snail, and it had now withdrawn into its shell. George held the shell quietly in his hand to see if the animal would not come out again. While we were waiting for this, Professor Parker asked us to count the heart beats of the animal. The shell was turned over and we observed a movement inside, to the left of the spot where the outer lip meets the body whorl. We moistened this spot a little and it became almost transparent, so that we could plainly see the beating of the heart through the shell. We were told that the heart was composed of the ventricle and the auricle, the former lying behind the latter. The pulsations were from right to left, the auricle seeming to push the ventricle at every pulsation. We now tried to count the number of pulsations in a minute. Harry held the watch while the rest of us counted. We found the number to be fifty. We then tried another snail to see if the number of pulsations were the same. Again we counted and this time the number was sixty-one. Professor Parker told us that the number of pulsations of the heart varied greatly, and that if we had the time to examine a large number of specimens, the number would be found to range from forty-eight to one hundred and six, the latter number being that of very young animals.

Not all of the snails which lived in the old log were as large as the white-lipped snail, some being very minute. While pulling off the rotten bark near one end of the log, Howard found quite a colony of the little *Pupa* shells. It took sharp eyes to detect them, for they were not larger than very small seeds, and lay very close to the under surface of the bark. With our pair of tweezers, we picked up a number of the little fellows, some of which were put into a small vial filled with alcohol, so that they would not dry up or stick to the sides of the bottle when dead. A few, we placed alive in a vial for study when we returned home. We examined one of the little specs with a hand lens and it appeared like the shell in the picture. The whorls were rounded, the spire quite long, and the aperture was modified by six teeth, or projections. When we saw the aperture so obstructed by teeth we wondered how the animal was able to crawl in and out. Professor Parker then said that in tropical countries, there live certain species of snails whose apertures are so contracted by teeth that scarcely any room is left for the animal.

Shell of Pupa, a minute land snail. The crossed lines at the right of the figure indicate the actual size of the shell. (Binney.)

Aperture of Pupa shell, greatly magnified. (Binney.)

Leaving the old log which we had turned over, we walked through the woods for a short distance, and soon came to another fallen tree, whose trunk was so rotten that it fell to pieces when we touched it. Breaking away the softer outside portion we soon found a part of the wood which was fairly alive with small, glassy snails less than a quarter of an inch in diameter, like those in the accompanying figure. These little shells, together with the *Pupa*, love to nestle under the loose bark of trees and in rotting trunks and stumps, such as we had just examined. The larger shells, like the white-lipped snail, hide under fallen tree trunks, among dead leaves, and in almost any other place affording protection from the sun.



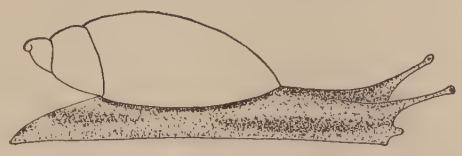
Four species of minute land snails. The smaller figures indicate the natural size. 1, Zonitoides arboreus; 2, Vitrea hammonis; 3, Vitrea indentata; 4, Zonitoides minusculus. (Morse.)

"Should we wish to see them crawling about and very active," said Professor Parker, "we must visit the woods just after a rain, when, in some localities, almost every bush, tree trunk, or stump will bear one of these animals. Moisture is an essential to their welfare, and they will not voluntarily live where the ground is dry. For this reason they are seldom found in forests of spruce and pine. Also a region where there is considerable limestone will produce larger and finer shells than one where this mineral is absent, because the limestone is necessary for the formation of the shell. A locality where there is a great quantity of quartz or flint is not conducive to the growth of land snails and few will be found in such regions. No land snail will live where sand, ashes, or lime, in a pure state, are found."

We ate our lunch on the mossy bank of a little stream, which ran merrily along over its rocky bed, and fell in tiny waterfalls as it tumbled over a ledge of rock. The forest rose on either side and the trees almost met overhead. At noon, the sun shone brightly through the boughs above, which cast fantastic shadows on the leafy carpet beneath the trees. Here indeed was a spot which needed the pen of the poet to do justice to its charms. After eating our lunch, we explored the stream for evidences of life. We did not have to search long, for Harry soon gave a glad shout, which told us plainly that he had discovered something of importance, and we saw him busily engaged in picking something from the leaves of the vegetation on the edge of the stream.

A nearer approach showed the object to be a snail with a long, graceful, yellowish shell. Looking about, we saw hundreds of them

crawling over the grass and even at the very edge of the water. The animal seemed much too large for the shell; in fact, Professor Parker told us that during the summer months the animal is not able to withdraw completely into the shell, but that on the approach of winter it becomes smaller, and is finally able to retract a considerable distance within the aperture. The head and neck of the animal were made especially notable by the presence of seven black lines. The eye peduncles were short and blunt, and the foot was half as wide as it was long.



Succinea ovalis crawling on the ground. (Magnified.)

Professor Parker said that the species of this genus (*Succinea*) inhabit moist localities, generally in the vicinity of water, and may be found crawling about on the vegetation along the margin. They are sometimes found on tree trunks at a considerable height from the ground. "*Succinea retusa*," continued the Professor, "is infested with a very curious, sausage-shaped parasite called *Leucochloridium americanum*, belonging to the fluke-worms, which modifies the tentacles to a large extent. Some birds, the thrushes for example, eat the infected *Succinea*, and the parasite develops in their intestines into the adult fluke-worm, or *Distoma*. Some of the fresh-water *Limnæas* are infested with a smaller worm, which changes into the fatal liver-fluke in sheep, which love to feed upon *Limnæas*."

In the moss which overhung a pool of clear water George found a number of glossy, horn-colored, turreted shells, about a quarter of an inch in length, which, we were told, bear the technical name *Cochlicopa lubrica*. Not far from this spot Harry picked up a number of *Succinea* shells from which the animals had been removed. They were of a beautiful rich, transparent horn-color. Some smaller specimens of a different species were of a rich rose color.

Cochlicopa lubrica, magnified. (Binney.)

Harry, who was the closest observer of the quartette, discovered some minute shells about one-twelfth of an inch long, which were white and pellucid, like spermaceti. These, Professor Parker told us, were members of the family *Auriculidæ*, which includes terrestrial shells that inhabit the vicinity of water. Their shells were graceful, and when examined with a hand lens, were very interesting. The other genera of this family inhabit salt marshes in the vicinity of the sea: their shells are generally much larger, and the apertures are filled with teeth. We spent the entire day in

the vicinity of this piece of woodland, and toward evening, having filled our boxes and bottles with specimens, we turned our footsteps toward the cars. As we reached the edge of the forest, we saw a particularly large log lying in a damp ravine, and we could not resist the temptation to turn it over and see if something new could not be found. Sure enough, there were several specimens of the solitary snail, *Pyramidula solitaria*. One of them was crawling over the damp leaves.

The solitary snail, Pyramidula solitaria. (Binney.)

Underneath another part of the log Howard discovered a whole colony of snails, the shells of which were about three-fourths of an inch in diameter, and marked by many reddish streaks on a horn-colored background. Several of the animals were crawling about, their method of locomotion being slow and careful. "This species," said Professor Parker, "is called *Pyramidula alternata*, and is our most abundant species. Unlike most of our *Helices*, it is gregarious, being generally found in colonies of from twenty to one hundred or more. The animal is sluggish in its movements, but is not at all shy, allowing itself to be picked up and examined without withdrawing into its shell. The shell is very variable in the height of its spire, some specimens having an elevated, convex spire, while others are perfectly flat. This variation is in a great measure due to the habit of crowding itself into narrow crevices, which causes the shell to assume a flat-whorled aspect. The convex forms are generally found in wide, open crevices, or under logs, while the flat-whorled forms are found in small, narrow crevices or under loose bark."

On the same log with this snail were several others in which the aperture was covered with a glistening film resembling parchment. George asked what this was, and Professor Parker proceeded to enlighten us. "This," he said, "is called an epiphragm, and with this the snail closes the aperture of the shell on the approach of winter. It is formed in the following manner: The animal withdraws into its shell, and places the parts of the body called the collar on a level with the aperture, and covers the latter with a quantity of mucus. A little bubble of air is now liberated from the lung, which detaches the film of mucus and makes it project in a convex form from the aperture. At the same moment the animal retreats farther into its shell, and leaves a vacuum between itself and the film of mucus. As the pressure of air is now greater on the outside, the film is pushed in and assumes

a concave form. This whole operation occupies but the fraction of a minute.

"As the weather gets colder, the animal withdraws farther into the shell, and new epiphragms are made until five or six of these partitions are formed. And what would you imagine was the purpose of this epiphragm? It is to protect the snail through the cold of winter when food is scarce or unobtainable. The winter's sleep is called hibernation. Other animals, as the bear and the raccoon, also enter into this sleep of winter, as you probably know.

"During hibernation, the heart almost ceases to beat, and all the functions of the body stop, the animal becoming torpid, to be awakened only when the warm days of April or May appear. In tropical countries, the snails hibernate during the hot and dry season, and are most active during the rainy season. The naked snails, or slugs, cover themselves with this secretion much as a caterpillar covers itself with a cocoon.

"The land snails are most active in the spring, when they may be seen crawling over fallen trees, on bushes, and on the ground. As fall and winter approach, they become less active, and finally prepare for the winter's sleep, from which many of them never awake, meeting death from old age, or falling a victim to some carnivorous animal."

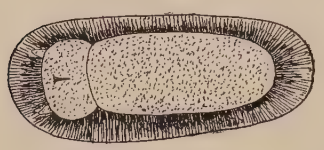
This old log produced a large number of species for our collections, some of which were new, and one in particular, called *Omphalina fuliginosa*, was especially large and fine. Here we worked until darkness had fairly set in, when we reluctantly left the prolific locality and returned home.

Omphalina fuliginosa. (Binney.)

AN EVENING WITH THE AQUARIUM AND SNAILERY

One evening, shortly after our trip to the woods, we met by appointment at Professor Parker's home for the purpose of spending a few hours in study. The Professor greeted us in his usual hearty manner, and we were soon deeply engrossed in our favorite subject.

Of great attraction to us was a large rectangular aquarium (about two feet in length and one foot in width and depth), which was tenanted by various species of pond snails, and fresh-water clams. A light was placed behind the tank, and thus we were able to study the habits of the imprisoned animals. A clam was slowly pulling its shell through the muddy bottom, its siphons extended, and the little cilia moving nervously about. Professor Parker told us to watch these siphons closely. A stream of water was constantly passing down the lower siphon, a fact of which we became aware by seeing several very small particles of vegetable matter float near the siphon and quickly disappear into its orifice. The upper siphon was violently expelling waste matter, and we could see the little particles thrown out into the water. We noticed that this siphon seemed to move like clock work, opening and closing at regular intervals, each time ejecting a current of water filled with waste matter. Out of curiosity we counted these pulsations and recorded twelve each minute.



Fresh-water limpet Ancylus rivularis, as seen through the side of an aquarium. Greatly magnified.

In another part of the aquarium, a number of pond snails were gliding slowly along. On one side, several large snails were eating the growth of green vegetable matter which had accumulated. This side presented a curious appearance, for each snail had left a clear path behind it where the scum had been cleaned off. We could plainly see the mouth open and close as the animal grazed along. Every time the mouth opened, the tongue was thrust out, and the whole operation reminded us of a cat lapping milk. The brown jaw was also plainly seen.

As we were watching the animals on the side of the aquarium, one of them rose suddenly from the bottom of the tank to the top of the water: there it floated, shell downward, and with the foot applied to the under surface of the top of the water. Sometimes a faint, clicking sound could be heard when one of the pond snails made this ascent. This, Professor Parker said, was caused by the escaping of the imprisoned air from the lung.

Pond snail. Limnæa mighelsi, crawling up the glass side of an aquarium.

George inquired how the snail was apparently able to crawl on the under side of the surface of the water, and also how the little insects called water-striders could run over the surface as though it were perfectly solid.

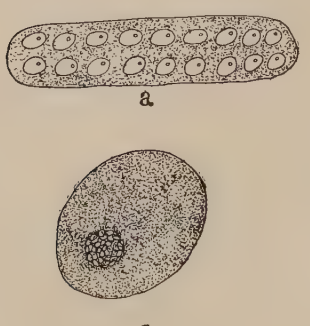
"This apparently impossible feat," answered the Professor, "is easily explained when we understand some of the laws of physics, and those of you who are studying the subject at the University are probably well acquainted with the fact. It is now a well-established fact that the surface of water and other liquids, is covered with a very thin film, and the insect is able to walk upon the upper side of this film and the mollusk on the lower side. One proof of the presence of this surface film is found by the oft-repeated experiment with the needle. If we carefully place a fine needle on the surface of the water, it does not sink, but will float, although seven times heavier than its own bulk of water. If the needle is wet, or if it is very large, it will not float, which shows that this film is very delicate. If we place the glass holding the needle so that we can look through the glass at the surface of the water, we will then see that the needle rests in a little hollow, as if the water were covered with a membrane."

Among the pond snails were a number of orb snails carrying their shells in a perpendicular manner, and waving their slender tentacles about. Several of them were crawling along the bottom of the tank, with a peculiar stepping motion. The animal pushed its foot deep into the sand, the shell being drawn well down toward the head. It was then pushed forward and upward, making a little furrow, which prepared the way for another step. In this way it "stepped" along at a lively gait. We learned from Professor Parker that this "stepping" was more for procuring food than for locomotion. One of the large orb shells was crawling up the side of the aquarium, eating everything in its path. Several times a morsel was taken which proved distasteful to the animal, and it was immediately "spit out."

Some of the smaller snails, *Amnicola* and *Valvata*, were wandering about, the former crawling with a wabbly gait, rolling the shell from side to side. In another part of the aquarium, a number of *Physas* were crawling rapidly along the bottom. Some of these rose suddenly, like the pond snails. Others descended from the top, suspended by a slender thread of mucus. Several of the pond snails had crawled out of the water, and were attached to the glass, a number of inches from the surface. Several apple snails, as well as other members of the water breathers, were enjoying themselves by crawling about the bottom, or on the sides of the aquarium, apparently feeding; their long tentacles were waving, and their blunt, cylindrical rostrum was moving about like the nose of a hound on the scent. All of this animation in the aquarium made it seem like a miniature world, as indeed it really was.

Tadpole snail. Physa gyrina, showing the tapering foot, digitate mantle margin, and long, slender tentacles.

On the narrow end of the aquarium we discovered a number of little, jelly-like masses, which Professor Parker told us were the eggs of the *Physa* snail. They were nearly an inch in length and very narrow. Each mass contained a large number of eggs. By the aid of a magnifying glass we counted the eggs in three masses, and found one hundred and thirty in one, one hundred and sixty in another, and two hundred in the third. The Professor placed one of these masses under the microscope, and we observed the little embryos slowly rotating about.



a

b

Egg mass of Physa gyrina. a, egg-mass, showing position of eggs in envelope; b, single egg, much enlarged, showing position of rotating embryo.

"The eggs of the fresh-water snails," said the Professor, "may be found any time during April or May. The young hatch out in June. They are transparent little animals, about one-fiftieth of an inch in length. They are very active, and eat voraciously of anything which they find. Some of the water-breathers lay but a single egg, which is inclosed in a round capsule. The young of the apple snails are born alive, and are minute, transparent animals, about one-eighth of an inch in length; they are very active."

Near the aquarium, the Professor had a snailery in which were several dozen snails of various species. The snailery was made of an aquarium about the size of the one in which the fresh-water snails and clams lived; the bottom was covered with earth to a depth

of three or four inches, and a little pan of water was sunk in one corner to imitate a lake; several small ferns were growing in the opposite end; a piece of netting was stretched over the top to keep the snails from escaping.

A snail was crawling over the moist earth, and we watched to see what it would do. It was evidently headed toward a fresh piece of lettuce leaf, which had been recently placed within. The snail went along slowly, moving its eye peduncles about nervously and retracting them when they came in contact with a lump of earth. Occasionally it would raise its head until it rested only upon the last third of its foot, and then, it would twist about its head and eye peduncles as though it scented danger.

Gastrodonta ligera, a common land snail. (Binney.)

In a little while the lettuce leaf was reached. Resting upon the hind part of its foot, it raised the fore part and began to bite off pieces of the leaf. We could see the horny jaw come out of the mouth, bite off a piece of lettuce, and then swallow it, accompanying the action by a faint rasping sound. Professor Parker told us that the jaw was used to bite off large pieces of vegetation, which were then reduced to pulp by the action of the teeth or radula.

The sight of the aquarium and snailery filled with living animals, fired our ambition, and we plied the Professor with questions relative to the immediate possession of aquariums and snaileries for each of us.

He smilingly encouraged us in our desire, and said that almost any kind of a glass jar or globe would answer the purpose. A fish globe was recommended, as was also an electric battery jar, and even a quart Mason fruit jar. The top, he said, should be covered with netting to keep both land and fresh-water snails from getting out and crawling about the room. Some floating water-plant in the aquariums, as duckweed, bladderwort, and watercress, with a few small ferns and some moss in the snaileries, would add to their beauty, and make them more homelike for their inhabitants.

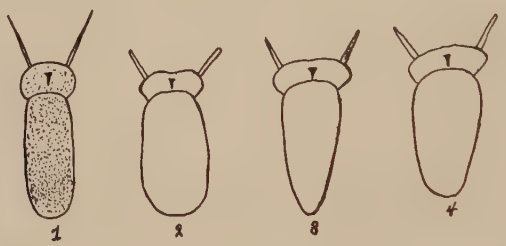
Circinaria concava. A carnivorous land snail. (Binney.)

We were warned against mixing different kinds of snails in one snailery, for while the majority are vegetable feeders, and perfectly friendly with each other, a few are carnivorous and would prey upon each other and also upon other snails. Such species as *Circinaria*, *Glandina*, and *Testacella* were to be especially avoided. We also learned that if there was not a sufficient amount of lime in the water of the aquarium, the snails would eat each other's shells to obtain this necessary

material. Professor Parker advised us to study the growth of some of the land snails; and as a preliminary lesson, he set us to hunting for some of the eggs in his snailery. After a few minutes' search, George found a little cluster of eggs under a projecting clump of earth. They were perfectly white, and about one-sixteenth of an inch in diameter.

The Professor told us that during May or June these snails lay their eggs, to the number of forty or more, in moist localities where they are sheltered from the rays of the sun. Favorite places are under old leaves which have space beneath them, by the side of logs, stones, or sticks, and under loose pieces of bark or chips. Twenty or thirty days after the eggs are laid, the young snail is hatched and starts on its life journey, reaching full maturity in about three years. In October or November, in this latitude (about 42 degrees north), the snail ceases to be active and hibernates during the cold winter months.

We asked Professor Parker how fast a snail could travel. This, he said, was a part of the subject which he had never studied: so he took a large specimen of the white-lipped snail from the snailery, placed him on a board, and took out his watch. The snail hesitated for a moment, and then started to crawl to the other end of the board. In one minute it had crawled two inches. He then again timed it, and it crawled twenty-four inches in fourteen minutes. He then tried a snail of a different species, and found that it took this snail two minutes to crawl two inches. Several other species were tried, and it was found that each seemed to have a certain regular speed, which did not vary to any great extent.



Four species of orb snails, showing the under surface of the foot as seen through the aquarium.
1. Planorbis bicarinatus.
2. Planorbis trivolvis.
3. Planorbis campanulatus.
4. Planorbis truncatus.

HOW SNAILS EAT

After we had examined and studied the aquarium and snailery to our satisfaction, Professor Parker remarked that he was ready for the work of the evening, which was to prepare and examine some of the teeth on the radula, or tongue, of snails.

Selecting a good sized specimen from a number which had been drowned the day previous, he showed us the oval mouth on the under side of the head, with the jaw and radula protruding. "The radula," he explained, "is inclosed in a rounded body called the buccal sac, which is placed at the fore part of the body, in the lower plane of the head. If we were to cut a section through the head and buccal body, it would present the appearance shown in this diagram which I have prepared for you. In some snails, as the apple snail, the radula sac is placed at the end of a retractile rostrum, or proboscis. The apparatus is protrusile, and may be plainly seen when a snail is feeding.

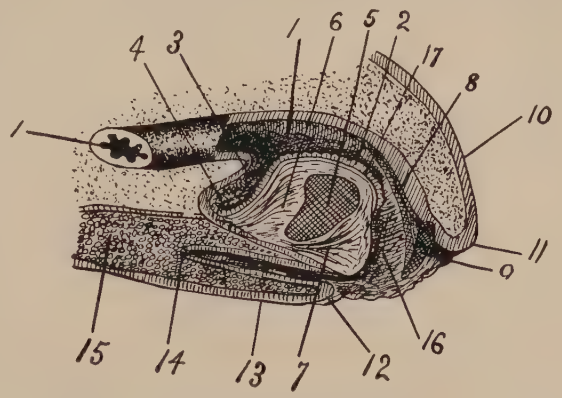


Diagram of buccal organs of land snail. 1, œsophagus; 2, radula; 3, core of radula; 4, new teeth forming; 5, cartilaginous substance beneath the radula, serving for support and for the attachment of muscles; 6, posterior cartilage muscles; 7, anterior cartilage muscles; 8, cartilage bearing jaw; 9, jaw; 10, outer surface of mouth; 11, upper lip; 12, lower lip; 13, under surface of lip; 14, orifice of mucous glands; 15, mucous glands; 16, mouth; 17, cells lining under surface of radula.

"The radula, or lingual ribbon, sometimes called the odontophore, is a strap of chitinous, or horny matter, and occupies a place in the mouth of a snail analogous to that occupied by the tongue in the cat and dog. It is formed in the radula sac, and grows forward as needed, much as does the human finger-nail. Just beneath the radula there is a stout cartilage to which are attached protractor and retractor muscles which move the cartilage backward and forward. The radula is strongly fastened to this cartilage at the anterior end. The forward action of the cartilage muscles brings the radula down between the two fleshy lips, where

a backward and forward movement takes place, the sharp teeth rasping off small particles of food.

"The horny jaw lies in the upper part of the mouth, and cuts off large pieces of food, such as leaves or other vegetation. The food is then acted upon by the radula, being pressed against the roof of the mouth, while the teeth rasp off small pieces, which are then swallowed. As fast as the teeth on the front end of the radula are worn out they

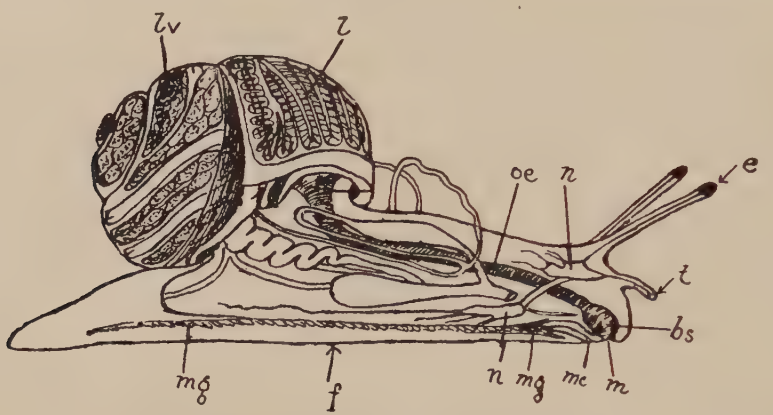


Diagram of animal of land snail, Helix, removed from its shell. The snail is in the position of crawling, and the organs are in their natural position. bs, buccal sac; e, eye-peduncle; f, foot; l, lung; lv, liver; m, mouth; mc, orifice of mucous gland; mg, mucous gland; n, nerve ganglia in head and foot; oe, œsophagus; t, tentacle. (Hyatt.)

are replaced by new ones which are pushed forward from the core of the radula sac. In this way the teeth are being constantly worn out by use and being replaced by new ones.

"The radula is one of the most important features in the classification of the Mollusca, and a knowledge of its characteristics is quite essential to any one who would seriously study the subject, as it is present in all classes except the clams or bivalves."

Having explained to us the function of the radula and its position in the animal, with a small pair of tweezers, Professor Parker deftly removed the jaw and radula of the white-lipped snail, placed it in a drop of Canada balsam in the center of a microscope slide, carefully lowered a cover-glass over it, and slipped it on the stage of the microscope.

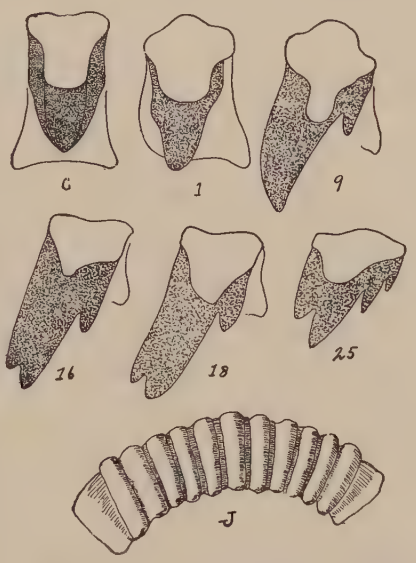
After adjusting the eye-tube, he motioned us to come and look through it. This we did in turn, and saw a flat background covered with peculiarly shaped teeth. The Professor changed the objective on the microscope to one of higher power and again asked us to look. This time we could make out only a few teeth, but each one was

clear and distinct and very large. As we moved the slide along on the stage of the microscope we observed that the shape and size of the teeth changed. The teeth seemed to become broken into several prongs toward the edge of the radula membrane.

Two rows of teeth on the left side of the radula of Polygyra tridentata, a common land snail. Magnified. (Binney.)

We called Professor Parker's attention to this characteristic, and he proceeded to explain the radula and how it is studied by scientific investigators.

"The teeth," he said, "are arranged in five longitudinal rows, each differing from the one next to it. Thus there is a central row, on each side of this, a lateral row; and outside of this, a marginal row. The central tooth is called the central, or rhachidian; the lateral teeth are known as admedian; and the marginal, as uncini. These teeth lie on the radula membrane, and are composed of a base of attachment which is fastened to the membrane, and a reflected or turned-over portion which bears the cutting points. This may be better understood by consulting this diagram which I hold before you. In studying the radula through the microscope, care must be taken not to confuse the reflected portion with the base of attachment. This mistake is easy to make, as each has a different focus, the reflected portion being higher and therefore nearer the observer.



Teeth and jaw of land snail. Polygyra pennsylvanica. c, central tooth; l, lateral tooth; 9, 16, 18, 25, marginal teeth; j, jaw. Greatly magnified.

"Each tooth in each row is made up of a number of different parts, which, in their diversity, serve to distinguish the different groups of mollusks Thus the central tooth may have a strong, squarish base of attachment to the radula membrane, and the reflected portion may be provided with three cusps or projections—a central cusp which reaches to the bottom of the base of attachment, and two side cusps which are shorter. Each cusp may also have a decided cutting point. The lateral and the marginal teeth may also be divided in the same manner.

"The majority of the teeth of pulmonate mollusks may be divided into two types: first, the quadrate, like *a* in this diagram of molluscan teeth; and second, the aculeate, like *c* in the diagram. The latter has no reflected portion, but a single, thorn-shaped cutting point arises from its sole-shaped base of attachment.

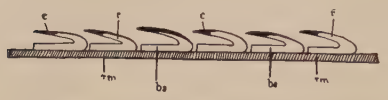


Diagram showing appearance of radula of land snail when seen in section. c, cutting point; ba, base of attachment of tooth; r, reflected or turned-over portion of tooth; rm, membrane to which the teeth are attached, called the radula membrane.

"In describing the radula, scientific men use a dental formula, similar to that used for designating the teeth of mammals. This formula describes the number and position of the teeth and cusps; thus, if a radula has a single central, three lateral, and twelve marginal teeth, and the first series has five cusps, the second series four, and the third series one cusp, the formula will be expressed as follows: $\frac{1}{1}^{2} + \frac{3}{4} + \frac{1}{5} + \frac{3}{4} + \frac{1}{1}^{2}$. The unit representing the tooth is written as a numerator, and the number corresponding to the cusp as a denominator."

Professor Parker now prepared another radula from a large pond snail, and before mounting it tore it in several pieces with the points of a pair of tweezers and a fine dissecting needle. We asked him what this was for, and he replied that it was necessary to separate some of the rows, as well as individual teeth, so that they would be more clearly seen, as they overlaid each other in their natural position, like shingles on a roof.

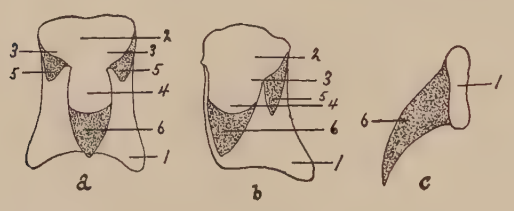


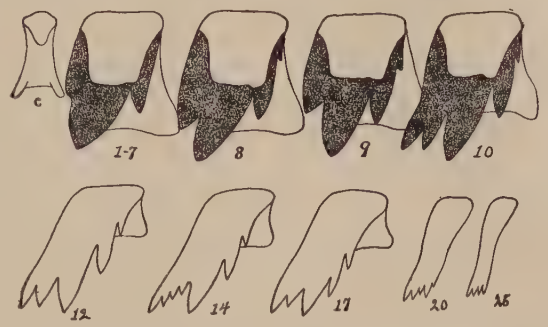
Diagram of the teeth on the molluscan radula. a, median; b, lateral; c, uncinal or marginal. 1, base of attachment to radula; 2, reflected portion; 3, side cusps; 4, median cusps; 5, cutting points of side cusps; 6, cutting point of median cusps.

We examined the radula, and saw that the teeth differed from those of the land snail in being differently shaped and in having more numerous cusps and cutting points. We also saw that tearing the radula made the teeth stand out more clearly, and they were not so mixed as when the radula was left in its natural condition.

When examining and making drawings of the teeth of the Mollusca, Professor Parker warned us to be very careful to note every feature accurately. The form of the base of attachment, of the reflection, the cusps, and the cutting points were all of importance. "Don't be satisfied," he said, "with making one examination, make several. After you have made your first drawings and notes, lay them aside

for a time, and then make some new ones. Compare these with the first ones and you will doubtless find a vast difference. After repeated examinations you will ultimately secure a perfect drawing and description."

After examining several more radulæ the Professor placed several types of jaws under the microscope for our observation. These were horny organs of various shapes, frequently armed with ribs or other projections.



Teeth of pond snail. Limnæa caperata. c, central tooth; 1–7, lateral teeth; 8, 9, intermediate teeth between lateral and marginal teeth; 10-25 marginal teeth. Greatly magnified.

When asked how many teeth a snail had on its radula, Professor Parker directed us to figure the number for ourselves from the radula of the white-lipped snail. This we did in the following manner: We first counted the teeth in one transverse row, beginning with the central tooth and counting each way toward the margins, and found eighty-nine teeth. Then counting the rows of teeth vertically we found that there were one hundred and twenty rows. Multiplying eighty-nine by one hundred and twenty we secured the enormous sum of ten thousand six hundred and eighty, the number of teeth in the mouth of a single snail!

Professor Parker told us that the number of teeth varies greatly in the different classes of snails. For example, a sea slug, *Æolis drummondi*, has but sixteen; the common whelk, *Buccinum undatum*, has two hundred and forty; and another sea slug, *Doris tuberculata*, has six thousand; the edible snail of Europe, *Helix pomatia*, has twenty-one thousand; while another snail, *Helix ghiesbreghti*, has the enormous number of thirty-nine thousand five hundred and ninety-six!

Jaws of land snails. Upper figure, Polygyra thyroides, a common land snail; lower figure, Limax flavus, a common European naked mollusk, or slug. Magnified.

George asked the Professor how it was possible to study the radula of some of the minute snails, like the *Pupa* shells. He replied that these must be boiled in caustic potash, and that he would prepare

one to show us how it was done. He first extracted the animal from its shell, and then placed it in a medium sized test-tube which contained a tablespoonful of caustic potash, which had become liquid by the attraction of the moisture in the atmosphere. He next lighted an alcohol lamp which made a good flame. Holding the test-tube firmly between the thumb and fingers of the right hand, he held it at the side of the flame, at the same time keeping the liquid in motion by a rolling movement of the thumb and fingers. He let it boil several times, being careful to avoid the boiling over of the animal matter, as it would stick to the dry side of the tube. This happened once, but he shook the liquid over it and it again fell to the bottom.

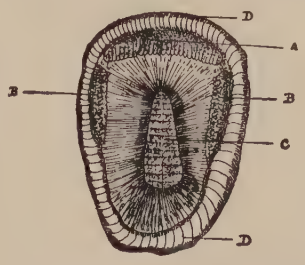
After the animal matter was dissolved, he quickly poured the liquid into a watch crystal, put a little clear water into the test-tube, shook it up well, and poured it into another watch crystal. He then placed the first watch crystal on a piece of white paper, and with the aid of a large hand lens searched for the radula. The watch crystal was given a gentle rotary motion, so that the solid particles in the liquid might be brought to the center. "The minute radula will be known," said the Professor, "by its long, curved form, and the little reticulations on its surface. If it is not in the first crystal we must examine the second. When it is found we will transfer it, with the fine tweezers, to the glass slide, and mount it in Canada balsam, as we did the radula of the large land snail. A much higher power of the microscope will be necessary for studying this radula, as it is much smaller.

"If the teeth are very transparent it may be necessary to stain them, and this may be done by putting the radula into a strong solution of chromic acid, which colors it a yellowish brown. It should be perfectly clean before it is stained."

Teeth of a water breather. Amnicola limosa. A, central tooth; 1, 2, 3, lateral teeth. Greatly magnified. (Stimpson.)

Having shown us the method of preparing the radulæ of small snails, Professor Parker placed the prepared slide of the radula of the snail (a species of *Amnicola*) under the microscope and bade us look at it. This we did, and we saw that the teeth differed very materially from those of either the land or fresh-water snails. The

central tooth was covered with little cusps, and there were only three teeth on one side, instead of thirty or forty, as in the other snails, and these teeth were long and narrow, the cusps showing as fine serrations at the upper end of the tooth. The Professor told us that many of the water breathers and marine snails possessed a radula with a few teeth on each side of a central tooth.



Mouth parts of pond snail. Limnæa reflexa. From drowned specimen. A, superior jaw; B, lateral jaws; C, radula; D, lips.

Before bringing our work of the evening to a close, we were shown a specimen of a common pond snail in which the mouth was open to its fullest extent, showing the three horny jaws attached to the lips and the radula situated far back in the throat. The Professor said that this was the only specimen he had been able to prepare showing these features so clearly.

As we were bidding him good night, he asked us if we would like to visit the museum again on the following Saturday and study some of the varieties of land snails. We quickly accepted his kind invitation, and promised to meet him at the museum promptly at one o'clock in the afternoon.

SNAILS OF THE FOREST AND FIELD

Promptly at one o'clock on Saturday afternoon our quartette of conchologists were at the museum, and were as promptly met by Professor Parker, who was waiting for us. We lost no time in ascending to the upper gallery where the mollusks were located. We went from case to case, and the Professor told us interesting and instructive facts concerning the specimens in each.

"Land shells are found almost everywhere," said Professor Parker, "in valleys, high upon mountains, and even in deserts. Many species live on Alpine heights of over thirteen thousand feet, while others love the beaches near the ocean where they are wet with the salt spray. Some are subterranean in habit, living underground in burrows, while others live among the limbs of tall trees, never visiting the ground. They may be found in the cold climate of Alaska and in the tropical zone, under the equator. As a rule, they prefer moist localities where there is abundant vegetation, and where the ground is strewn with rotting logs, beds of decaying leaves, or moss-covered rocks. In the northern part of the United States, open woods may be said to be their best habitat.

Vitrea cellaria, a common European land snail. It has also been introduced into the greenhouses of the United States. (Binney.)

"As you have already learned, land snails breathe by means of a so-called lung, which is a sac lined with a network of blood-vessels, occupying the last turn, or whorl of the shell. The air taken into the lung purifies the blood. They are called *Pulmonata*, or air-breathers, for the reason that they possess a lung and breathe air directly, instead of through the medium of water.

"The shells of the *Pulmonata* vary to a wonderful degree in size, shape, and coloration. Some are so small that they can scarcely be seen with the naked eye, while others attain a length of six or more inches; some have the aperture of the shell modified by numerous folds, or teeth, while others are smooth. The colors vary from whitish or horn-colored, to the gorgeously colored *Helices* of the tropics, with their bands and blotches of red, brown, white, and green. With all this diversity, the land shells may be easily distinguished from their

FROM COL. CHI. ACAD. SCIENCES

COPYRIGHT 1900, BY A. W. MUMFORD, CHICAGO.

LAND SHELLS.

Epiphragmophora fidelis (California).
Cyclophorus appendiculatus (Philippines).
Polygyra albolabris (U. S.)
Polygyra profunda (U. S.)
Omphalina fuliginosa (U. S.)
Cerion microstoma (Cuba).
Clausilia macarana (Dalmatia).
Helix pomatia (Europe).
Acavus haemastomus (India).
Nanina lamarkiana (Philippines).
Achatinella (Sandwich Islands).
Drymaeus multilineatus (Florida).
Liguus fasciatus (Florida).
Strophocheilus chiliensis (South America).
Glandina truncata (Florida).
Cochlostyla intorta (Philippines).
Helix nemoralis (Europe).

salt and fresh water relatives. The tropical land shells are much sought after by collectors.

"The desert snails are generally pure white. Like that of many other animals, the color of the snails is in a measure protective, rendering them more or less inconspicuous to their enemies. Thus the desert snails live in sandy regions, and are whitish; the Philippine tree snails live among the variously colored leaves and branches of trees, and are of many colors; while those species which live among moss, dead leaves, and under logs, are horn-colored, or greenish.

"We hear much of late," continued the Professor, "about our new possessions, the Philippine Islands, but few people are aware that some of the most beautiful of the land snails live there. These are the *Cochlostylas*, or tree-snails, which live for the most part among the branches of trees and bushes. The animals are large and bold, and their shells are of surpassing beauty, with their colors of white, green, brown, horn, and many other shades, as you will see when you look in this case, which contains several hundred specimens. The island of Luzon has probably the best known fauna, and it is to be hoped that the United States government will soon complete a natural history survey of all the islands, so that we may know more of these interesting creatures.

"The land shells of the United States, while numerous in species, are not as conspicuous in color pattern as are those of Europe, South America, or the islands of the Indian and Pacific Oceans; however, California produces some highly colored species, for example the *Epiphragmophora fidelis*. The majority of our species are free from bright colors, as is the common white-lipped snail, *Polygyra albolabris*.

Bulimus oblongus, a Brazilian snail which lays calcareous eggs. (Tryon.)

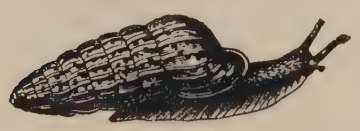
"One of the largest and most interesting of American shells is the *Bulimus*, found in South America. The shell of *Bulimus ovatus* attains a length of six inches, and the animal is correspondingly large. In the markets of Rio Janeiro this mollusk is sold as food, and is eagerly sought by the poorer people, among whom it is considered a great delicacy. Another interesting fact in connection with this species, as well as others of the genus, is the size of the eggs which it deposits, they being as large as pigeons' eggs. These are also eaten with avidity by the negroes of Brazil.

"One of the most beautiful of the land shells living in the United States is the *Liguus fasciatus*, found in Florida and also in Cuba.

The shell is about two inches long, and is encircled by bands of white, brown, and green. This species lives in great numbers at Key West, where it is associated with many small shells of the *Bulimulus* group. Closely related to the last-mentioned shell (*Liguus*) is the agate shell, *Achatina*, which attains a length of seven inches, and is the largest of the land shells. Like the *Bulimus*, it lays eggs of large size, inclosed in a calcareous shell, some being over an inch in length. Both the animal and the egg are eaten by the natives of Africa. The shells are very attractive, being variegated with different colors, as are the agates, from which they receive their common name.

"Another of our recently acquired political possessions, the Hawaiian Islands, has a molluscan fauna peculiar to itself. This is the family *Achatinellidæ*, which is confined solely to these islands. There are no shells that can compare in beauty with the *Achatinellas*, with their encircling bands of black, yellow, white, and red. They live on the bushes, generally rather low and near the ground. A bush inhabited by these little creatures must be a beautiful sight, with the green foliage decked with their handsomely colored shells, like jewels on a costly dress. These mollusks have been recently threatened with extinction, because of the cattle which have been introduced into the islands. These cattle, while feeding on the bushes, also consume large quantities of the snails. This is a good example of how man disturbs the balance of nature.

"*Achatinella* is not the only group of snails having a restricted geographical distribution. The genus *Cerion*, comprising cylindrical, pupiform shells, is somewhat restricted, being confined to the West Indian Islands with the exception of two species which live in southern Florida. It is also a curious fact that not a species of this genus is found in Jamaica nor in the islands of the Caribbean Sea. The name *Cerion* is from the Greek word *Kerion*, signifying honey-comb, and is given to these shells because the form of the spire resembles that of a bee-hive; hence they are called bee-hive shells. These mollusks are peculiar, in living in the full glare of the tropical sun. Probably for this reason their shells are whitish in color and are usually without color markings. Shells of this genus are frequently found living in hot, dry localities where most snails would quickly die. In this respect they resemble the desert snails.



Cerion chrysalis, showing position of shell when the animal is in locomotion. (Tryon.)

"Among the edible snails, none excel in public favor the common edible snail of Europe, *Helix pomatia*. The cultivation of this snail

has become an established industry, similar to our oyster fisheries, and thousands of snails are consumed annually. The early Romans considered this animal a dainty dish, and the inhabitants of France, Spain, and Italy have inherited or cultivated a liking for the succulent "shell-fish." This snail has been introduced into New Orleans where it is eaten by the French inhabitants. *Helix nemoralis*, an edible snail of England, with a beautifully banded shell, is sold in the streets of London and eaten much as we eat walnuts, by picking out the animals with a pin. Owing to their large size, the edible snails make good and valuable pets in captivity. It is interesting to watch one of these snails feeding upon a piece of lettuce, the jaw and radula being plainly visible while at work. *Helix pomatia* is of a very inquisitive disposition, and will wander about the snailery, or even the whole house, if it can get out, examining everything in a very curious manner.

"The most interesting snails are by no means the largest. Frequently the small snail shells, with their animals, have habits or shell structures of absorbing interest. Among these are the *Pupas*, whose tiny shells frequently attain the incredible size of only one-sixteenth of an inch in length! It is not until we place these mites under the microscope that their interesting characteristics are seen and appreciated. By such an examination, we find that the little apertures are modified by many teeth and folds, and we sometimes wonder how the little animal is able to get in and out through such a labyrinth of apparent obstructions. These teeth are said to serve in a manner to protect the animal from its enemies. These tiny shells are always to be found in great numbers under starting bark, and under chips, stones, and debris, in more or less moist localities.

"In another genus of *Pupidæ* (*Clausilia*) nature has provided the aperture of the shell with a little valve, called a clausilium, which acts as a spring door to close the shell against all enemies. This door is an additional safeguard, as the aperture is already provided with numerous teeth and folds.

"It is a curious fact that in the larger groups of animals there are one or more genera which have the cruel and bloodthirsty character of the shark or tiger. The Mollusca are no exception to this rule, and we find in the genus *Testacella* of Europe an animal having all of the ferocious propensities of the man-eating tiger. This mollusk has a long, worm-like body, the ear-shaped shell being very small and rudimentary, and placed on the posterior end of the animal. Its principal food consists of earthworms, although it will attack other mollusks, and even its own species. It has been likened to the tiger

The forest home of the snail.

and the shark, in its cunning while pursuing its prey, and in its ferocity when attacking it. The poor earthworm stands but a slight chance of escape when *Testacella* scents it and starts in pursuit. The earthworm tries to escape by retreating into its underground galleries; but this is of no avail, because the mollusk has a long, narrow body, and can go wherever the worm does. If the worm, perchance, has the opportunity of retreating far into its galleries, the mollusk will dig tunnels to intercept it. Frequently the mollusk will make a sudden spring upon its victim, taking it by surprise. This slug-like animal will frequently devour a snail much larger than itself; but if the victim is too large, it will be broken in the middle, and one-half eaten and digested, and then the meal completed with the other half.

"The *Testacella* also resembles the tiger and the shark in the possession of long, fang-like teeth upon the radula. These teeth are recurved, and aid the mollusk in getting a firm hold upon its victim, and also assist in the operation of swallowing. It is a curious fact that this animal will not feed upon dead animals, nor upon fresh meat, or freshly killed worms. Like the snake, which it greatly resembles in some respects, it must hunt and kill its own food. Its wanderings are nocturnal, as is the case with most of the land shells, and particu-

larly the slugs, and during the day it remains concealed in burrows in the earth. *Testacella* is quite long-lived, as snails go, its duration of life being about six years.

"A genus allied to *Testacella*, and having the same predaceous habits, but protected by a large shell into which the animal can withdraw, is the *Oleacina*, or *Glandina*. The shell is long, with a narrow aperture, and an elevated, dome-shaped spire; the animal is long and narrow, and the head near the mouth is furnished with a pair of elongated lips, which may be used as tentacles. The South American species feed upon the larger mollusks, as the *Bulimus*, and the aperture of each intended victim's shell is carefully examined before any attempt is made to enter. When the 'tiger' is satisfied that its victim is really within, it will enter the aperture and devour the animal. Sometimes it will make a hole for itself in the shell of its victim, and will eat the contents through this aperture instead of the natural one. In Florida, the *Glandina* preys upon the large pulmonates, as *Liguus* and *Orthalicus*.

"Still another land shell with tigerish habits is the *Circinaria*, which has a flat, spiral shell. A species in California reaches a diameter of one inch; but the species found in the eastern and central parts of the United States are not much over half an inch in diameter, and are very common in some localities. It is a perfect cannibal, and will quickly 'clean out' a snailery of half a dozen or more *Helices*. Thrusting out its long, narrow body, it crawls into the shells of its victims, and no matter how far the latter may contract within their shells, it is of no avail against the carnivorous appetite of *Circinaria*. It preys upon its own as well as upon other species, thus being in truth a cannibal.

"In this case," said Professor Parker, pointing to a large upright case in one corner of the gallery, "preserved in alcohol, is a collection of slugs, or snails without external shells. These animals are very common in Europe, where they attain a large size. They are rather solitary in habit, living in the woods under fallen trees and stones. Some species live near the seashore. Their food consists principally of fungi and the tender shoots of plants. Instances have been known of their committing cannibalism, especially when very hungry and when several specimens are together. The native species

Limax flavus, a slug, or snail without an external shell. (Binney.)

of the United States are mostly rather small, although several very large species live in the states of the Pacific coast. Some of the smaller species, notably *Limax campestris*, have the curious habit of suspending themselves from some object by a thread of mucus. Some of the larger European species of *Limax* and *Arion* have been introduced into this country, and are now found in many of the greenhouses of the larger cities. In some localities they have invaded the cellars of private residences, where they feed upon meat and vegetables. Occasionally a housewife finds one in her milk-pan. In one city in the state of New York, *Limax maximus* has escaped from the greenhouses, and may be found in almost any yard, under boards, barrels, or boxes, and even under board sidewalks.

"These slugs, as well as some shelled snails, are very injurious to farmers and horticulturists, as they eat the tender shoots of plants and vegetables. In the greenhouses, these animals are sought after daily and killed by being placed in boiling water. The story is told of a man who tried to raise tomatoes on one of the Florida Keys. He noticed that as the fruit became ripe it was eaten by some animal which left nothing but the skin. Investigation revealed the fact that every night a host of slugs, called *Veronicella*, issued from the holes in the sponge-like coral and devoured the fruit. Against this invincible enemy, the raiser of tomatoes could not fight and he was forced to give up his gardening.

"A good way to keep slugs out of a cultivated patch, is to spread a belt of dry ashes, about two feet in width, around the plot of ground. When the mollusk meets this obstruction it will secrete mucus so fast that it will soon die from exhaustion. The slugs, as well as all land shells, are preyed upon by birds, reptiles, and other animals, which in a measure keep their number within reasonable bounds. Turtles are particularly fond of some varieties of snails, and a large number of beetles have been observed feeding upon the succulent mollusk. It is an unvarying law among the lower animals that the small individuals eat those still smaller, and they in turn are eaten by the larger animals."

As we were leaving the gallery, George inquired how long land snails live. Professor Parker answered and said: "The large majority live but a year or two. The desert snails, which spend half of their lives in hibernation, live much longer, probably six or eight years. Instances are known of the desert snail living without food for five years while in a state of hibernation, and specimens which have been glued to tablets in a museum have apparently come to life after being on exhi-

bition several years. This habit of hibernation has enabled land snails to be carried many hundred miles from their natural habitat, and has very largely widened the geographical distribution of some species.

"It is interesting to study the methods by which many species of shells have been carried from one country to another. Land shells may be hidden in fruit, grain, or other merchandise, while the marine snails may become attached to the bottom of vessels, or to the bodies of other animals. The driftwood along the shores of rivers may be carried many hundred miles and thus disperse the mollusks attached to the wood over a large area. Clams have been known to close their shells upon the feet of birds and turtles, and have thus been carried from one pond to another. The most effective method of distribution among the marine snails is by the free swimming larvæ, which often swim many miles from their birthplace before settling to the bottom of the sea.

"The air-breathing snails which we have studied this afternoon," continued Professor Parker, as we left the museum, "are but a limited number of the many thousand species of this very interesting group of animals. Their shells are so easily gathered, and require so little trouble to prepare for the cabinet, that I would advise you all to make a collection of them. If you have no engagement for Monday evening, I should be pleased to have you spend it with me, when we can study the methods of caring for and labeling such a collection." We gladly accepted his invitation, and promised to be at his house at an early hour.

WHERE MOLLUSKS CAN ALWAYS BE FOUND

Photograph by F. M. Woodruff

HOW TO PRESERVE A COLLECTION

On the Monday evening following our visit to the museum, we met at the home of Professor Parker to help him sort and preserve some collections which he had made several days before. His work-room was large and airy, provided with running water and a good sink; the tables were covered with pans, bottles, files, tweezers of various sizes, an alcohol lamp, and a compound microscope. The aquarium which had so interested us on a previous visit, was placed near the window, and on the opposite side of the room was a large bookcase filled with books on conchology, birds, and other branches of natural history.

The Professor greeted us cordially, and immediately set us at work. We first separated the clams from the snails, and placed them in different pans of water, after which we proceeded to extract the animal from the clam shells. This we did by placing the shells in lukewarm water, and then heating the water to the boiling-point. This killed the animal, and made the valves of the shell separate. The boiling water also prevented the epidermis from cracking. Professor Parker told us that it was always better to place the shells in lukewarm water at first, in order not to crack delicate shells, and also to preserve the natural gloss. The adductor muscles were next cut, and then the animal was easily removed from the shell.

After cleaning the clams in this manner, we washed them thoroughly under the faucet, and then tied the valves together in their natural position. The Professor cautioned us to be very careful in cleaning the shells, in order not to injure the ligaments. We were told to grease the outside of the shell with vaseline, which would aid in keeping the epidermis from cracking. After greasing them thoroughly and rubbing the vaseline in with a flannel cloth, we removed all surplus grease, so that the shells might not feel sticky. We then placed all of the shells in rows on boards and put them away on a long shelf to dry.

In one of the clam shells which George had opened he found a little, round, pearly object, and he asked Professor Parker what it was. "That," said the Professor, "would have been a rather nice pearl if it had not been boiled. These pearls are frequently found in our fresh-water bivalves, and are caused by some irritating substance becoming lodged in the soft part of the animal. This forms a nucleus which the clam

covers with smooth pearly matter to prevent irritation. The beautiful iridescence is caused by light falling on the edges of transparent plates. The nucleus of the pearl may be any foreign substance, like a grain of sand, particle of food, or a parasitic worm. Spherical pearls are frequently found loose in soft parts of pelecypods, particularly in the muscles.

"While we are discussing the subject of pearls, let us look at a broken shell of a *Unio*. If you observe this closely with a hand lens you will see that it is composed of three distinct parts. Now, if you will look at this section, which I have prepared for the microscope, you will see that the shell is made up of an outer layer, composed of almost black tissue, a layer of columnar tissue set at right angles to the first layer, and a third or prismatic layer, which forms the inner surface of the shell, and is composed of thin plates of membrane and carbonate of lime placed alternately. It is the effect of the rays of light falling on the edges of these transparent plates which gives to these shells, and also the pearls which the animals produce, their beautiful iridescent luster."

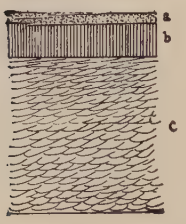


Diagram of a section of the shell of fresh-water clam, showing the three shell layers. a, epidermis; b, columnar layer; c, prismatic, or inner layer.

After finishing the larger clams, we cleaned a number of the smaller shells belonging to the genus *Sphærium*. Upon opening some of these clams, we found a number of smaller shells, which were about one-sixth the size of the larger shell. These, the Professor informed us, were the young of the *Sphærium*, which are born alive and not hatched from eggs. He also added, that they are very active when young, climbing about water-plants, and seeming to thoroughly enjoy themselves; and that they frequently suspend themselves by a thread, called a byssus.

Having prepared and cleaned the bivalves, we turned our attention to the snails. In order to kill the animal, these were treated in the same manner as were the clams, after which the soft parts were extracted with a piece of wire bent into a spiral and sharpened at one end to a fine point. Many of the snails, especially the apple snails, were covered with hard mud which it was necessary to remove. This we accomplished with a tooth-brush. Some of these specimens were badly stained with iron, and although we scrubbed them dillgently, the stain would not come out. Noticing our predicament, Professor Parker took a bottle of oxalic acid solution and told us to place them in this for a few moments. Following his advice, we found that they were cleaned perfectly.

He also made each of us a good snail extractor by taking a pair of hat pins and heating them over the gas flame. With a pair of pincers he twisted the pin into a spiral of two turns. Then he heated it again,

and plunged it into a pan of cold water to restore the temper of the steel. Thus we had an excellent tool for extracting the animal from spiral shells.

Some of the fresh-water snails possessed an operculum, and this we carefully removed from the foot and placed it beside the shell from which the animal was taken. When the shells were perfectly dry, the aperture was filled with cotton, and the operculum fastened to it in its natural position with a little glue. We were told that in some snails the operculum is so large that it curls up when drying, and that such opercula must be placed between two pieces of wood tied tightly together until perfectly dry.

Some of the fresh-water snails were covered with incrustations of lime, which we removed with the sharp point of a file, after which a good scrubbing cleaned them very nicely. When dry, the larger fresh-water snails were treated with vaseline in the same manner as the clams, which gave them a fine gloss.

Professor Parker had accumulated a number of land shells in his snailery, which he asked us to clean for him. These we placed in boiling water, extracted the animal, washed the shells thoroughly, and placed them on a board to dry.

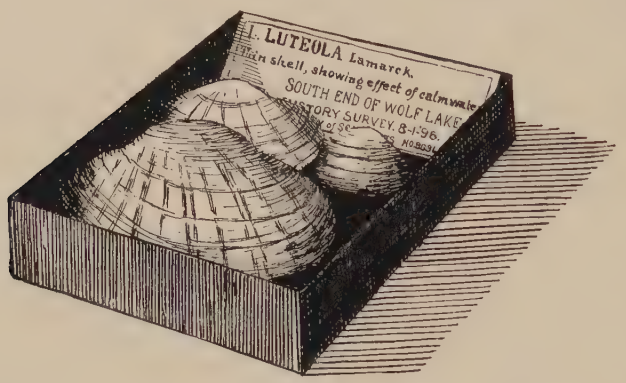
Some slugs had been drowned the day before by placing them in a vessel completely filled with water so as to exclude the air. This killed the animal in an extended position, the eye peduncles and tentacles being stretched out to their fullest extent. Many of the snails had also been treated in this manner. When completely drowned they were removed to alcohol, the strength of which was gradually increased. We asked the Professor how long it took to drown a snail, and he said about twenty-four hours. When we asked how long it took to harden the slugs and snails, he answered by giving us the following formula on a piece of paper: 30 per cent alcohol, 24 hours; 70 per cent alcohol, 30 hours; and 85 per cent alcohol for final preservation. He also said that a 1 per cent solution of chromic acid would accomplish the same purpose; and that the specimen of moderate size might be hardened in about thirty hours, after which it should be thoroughly washed in running water for twenty-four hours, to remove all of the acid. All of these facts we carefully recorded in our note-books, for future reference.

From some of the slugs we removed the little, flat, internal shell, cleaned and dried them for the cabinet. The very small snails and clams we placed in alcohol for fifteen or twenty minutes, and then dried them. This removed the moisture and prevented any unpleasant odor.

We asked Professor Parker whether it was necessary to have a differ-

ent lot of tools, or if the work were done differently in preparing marine shells for the cabinet. He assured us that the same apparatus and method of procedure would answer equally as well for marine shells. In some large species it was necessary to use a syringe to remove all of the animal matter from the spire. We were told that this was necessary to keep the museum insects from ruining the appearance of the collection.

The Professor now showed us a new cabinet which he had just received, and in which he had arranged some of his recent acquisitions. This cabinet was about five feet high, and inside the drawers measured a little more than two feet square, and were two inches in depth. The specimens were all neatly arranged in pasteboard trays covered with black glazed paper. He said that he formerly used white trays, but found that they were too easily soiled. The trays were half an inch deep, and were made in interchangeable sizes, as follows: 2 x 3, 3 x 3, 4 x 3, 4 x 6, and 6 x 6 inches. At the upper part of the drawer were several trays 1 x 3 inches, turned upside down, upon which was pasted the name of the genus to which the shells belonged. The labels were written with india ink, and were fastened to the tray by simply gluing the upper edge, as shown in the cut above. This method prevented the specimens from rolling on the label and hiding it.



A tray of specimens, illustrating the method of labeling.

The labels were made of manila pasteboard, and each one bore the name of the species, its locality, from whom received, the date, a consecutive number, and a few notes relative to the specimens or the locality. The number on the label referred to a book called an accession catalogue, in which the Professor had entered each species, giving all possible information regarding it, such as exact locality, kind of shore, whether rocky, sandy, or muddy, and if a fresh-water shell the size and kind of pond or stream, whether sandy, rocky, reedy, etc. The date and temperature were also carefully recorded, besides brief mention of the habits or peculiarities of the animals. In addition to the accession book, he also kept a card catalogue which showed at a glance how many species of a given genus were in the collection. All of this seemed very desirable,

and we determined, at the first opportunity, to arrange our collections in the same manner.

The very small, minute species were exhibited in little bottles or vials, in which was placed a number corresponding to that on the label. This was a very necessary precaution, the Professor told us, to guard against the contents of the trays being spilled, and so mixing up the collection.

Before we left the Professor's house for our homes he asked us where we expected to spend our vacations. We told him that we had planned to spend a few weeks together on the seashore, and that we would be in Providence, Rhode Island, about the middle of July. He made us very happy when he said that he also expected to visit the coast during the summer, and would be in Providence about the time that we were to be there. He added that he would be pleased to plan some collecting trips with us to obtain marine shells and clams, so that we might compare them with their fresh-water relatives which we had already studied. We bade him good night, and returned to our homes, our hearts stirred with the anticipation of a few weeks to be spent on the seashore in company with our friend and instructor.

THE BEACH AT LOW TIDE

Photograph by F. M. Woodruff

ON THE BEACH AT LOW TIDE

As treasures that men seek,
  Deep-buried in sea-sands,
Vanish if they but speak
  And elude their eager hands.
— LONGFELLOW.

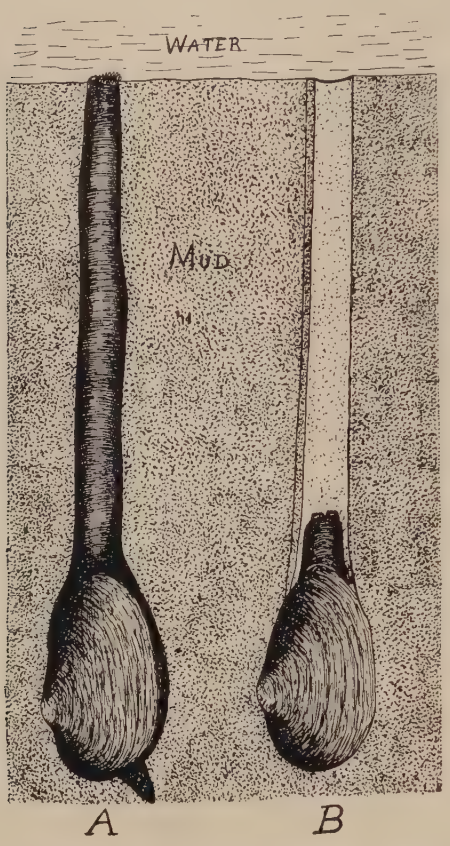
One morning in the month of August, our quartette of conchologists with Professor Parker, boarded the little steamer at Providence, Rhode Island, for a trip down the bay. Our destination was a small place called Rocky Point, where it was our purpose to dig clams and collect the various species of mollusks which live on the rocky shore. The ride down the bay was delightful, and the scenery was very beautiful. On either side, the hills rose from the water and stretched far away in soft undulations, their sides green with grass and trees, and their gentle slopes dotted here and there with the cottages of those who were spending the summer in this delightful region. A fresh sea-breeze was blowing, and the buoyancy caused by this pleasing aspect of nature made us feel equal to almost any emergency.

After a ride of about an hour we arrived at Rocky Point. On this occasion, our collecting outfit consisted of two spades, several baskets, some wide-mouthed bottles (one of which contained alcohol), a number of glass vials for any small shells which we might find, and the ever ready tweezers.

The tide was out, and a long stretch of muddy beach lay before us, with here and there a pool left by the retreating water, or a rock covered with seaweed, barnacles, and sea-moss. We made our way across this stretch of mud, our objective point being a smooth portion of the beach some three-fourths of a mile distant, where clams were said to be abundant. As we walked along, little jets of water shot up here and there, showing where a clam had become alarmed and had shut his door suddenly, causing the little water-spout.

Arriving at our destination, we were soon prepared for wading; then two of our number took spades and began to dig. At the first movement of the spade, up shot the tiny water-spouts in every direction, showing that the clams were there "in force." A little

digging soon brought to light a whole spadeful of clams mixed with mud, and we all gathered around to pick out some specimens for our collections. They were the soft-shelled clams, having white shells and remarkably long, black siphons. Upon close examination we found that the siphon was not one tube, but two tubes joined together. Professor Parker told us that when the clam is in its natural position it is buried nearly a foot below the surface of the mud, and its siphons are stretched out until the end just reaches a little above the surface. In this position the lower siphon is the larger, and is fringed with little whip-like organs called cilia. The other siphon is smaller, and is without the larger cilia. When the clam is disturbed, either by footsteps or by some enemy, it violently retracts the siphons, thus causing the water in its shell to shoot up in a little spout. When the clam is covered by the sea, all of the little cilia are engaged in pumping currents of water down one siphon and up the other; but when the tide is out, the clam stops working and remains quiet, with its siphons fully extended. However, should an enemy alarm it, the siphons are suddenly drawn in.



Soft-shelled clams, Mya arenaria, buried in the mud in natural positions. A, with siphon extended; B, with siphon contracted.

We spent the morning digging clams, and by noon had accumulated nearly a bushel. Gathering together a lot of seaweed, some driftwood, and a few large stones, we built a fire in an inclosure formed by the stones, put on the seaweed, and soon had a nice lot of clams baking for our dinner.

While Harry was busy preparing the dinner, the rest of us walked along the shore to pick up any good specimens which the tide might have washed in. At the point which marked the height of the tide, there was a line of debris called sea-wrack, which proved to be a perfect mine for specimens, and we gathered no less than twenty different varieties of clams and snails. The Professor told us that such a locality

was always a good one for shells and other animals which the tide had washed in.

At one place we came to an elevated bank, which was solid with black edible mussels, *Mytilus edulis*. There must have been literally millions of shells attached to the bank and to each other, by their byssus of little silken threads. Among the mussels we found periwinkles, bubble shells, slipper shells, and a host of others. Not the least interesting inhabitants of this mussel bank were the fiddler crabs, which scampered off in every direction as we approached, holding their one enormous claw ready for battle. They soon disappeared in their holes, their claw and big pincer being visible just below the edge of the hole.

The black mussel, Mytilus edulis, showing byssus, by which it attaches the shell to some object. (Binney's Gould.)

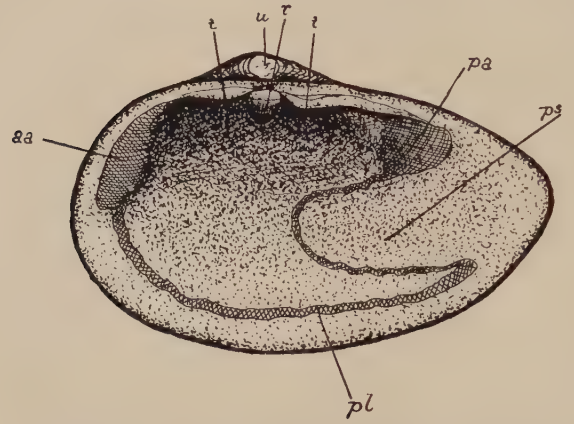
Returning to our camping-ground, we found awaiting us a good dinner consisting of baked clams, bread and butter, and a generous slice of apple pie for each one. After dinner, Professor Parker proceeded to give us a lecture on clams, and we willingly gave him our closest attention.

We were first told to examine the outside of the shell, and note the brown, horny covering called the epidermis, which protects the limy shell from injury by any carbonic acid which may be in the water. As in the fresh-water clams, the soft-shelled clam has a rounded anterior end and a wedge-shaped posterior end; a sharp ventral margin and a rounded dorsal margin, with the two beaks, or umbones, placed a little in front of the center of the shell. The two valves are alike, and the animal is therefore bilaterally symmetrical. It was noted that the anterior end closed tightly, while the posterior end opened, or gaped, to allow the siphons to be extended.

Removing one of the animals from the shell, Professor Parker pointed out its different parts, and their relation to the animal. In the right valve we noticed the large scars of the adductor muscles at either end of the shell, and the deep pallial line connecting them and showing where the mantle of the animal was attached. Our attention was called to the fact that this line was not straight, as is the case with the fresh-water clam, but was curved, and had a bay, or sinus, at the posterior part, called the pallial sinus. This showed that the animal

had long, retractile siphons, and was a burrower in the mud. "All bivalve shells with this kind of siphon," said the Professor, "have a pallial sinus in the shell, while those with short, non-retractile siphons are without a sinus, as is the fresh-water clam.

"In the fresh-water clam the dorsal part of the two shells are fastened together by a ligament, and the valves are aided in opening and closing, by a set of cardinal and lateral teeth. In this soft-shelled clam, however, no such apparatus is present; but in its place there is in the left valve a broad shelf extending from the hinge, on which there is a long tooth, and a tough piece of brown cartilage called the resilium. In the right valve there is a depression and a heavy ridge, which fits into a corresponding depression in the left valve. This resilium forms a cushion which is constantly pushing the valves apart.



Interior of right valve of clam. aa, anterior adductor muscle scar; pa, posterior adductor muscle scar; pl, pallial line; ps, pallial sinus; r, resilium, or so-called cartilage; t, tooth-like enlargements of the hinge corresponding to the teeth of the fresh-water clam; u, umbo.

"It will be remembered that in the fresh-water clam, the tough ligament pulled the two valves apart by contraction; but in the soft clam the elastic cushion is constantly pushing the valves apart. In both cases, the adductor muscles have to overcome the strain to keep the valves together. The resilium is not a true counterpart or analogue of the ligament, but it is a part of the latter which has become separated from the true ligament, which is reduced to a mere trace in this clam, because of its burrowing habits.

"The interior of this shell is not lustrous and pearly, as in the fresh-water clam, but is white like porcelain. For this reason the shell is called porcellanous. The outside of the shell is very much roughened by many concentric lines or ridges, which show where the animal added to the size of its shell as it grew larger. The heavier ridges indicate rest periods and by counting them we are able to tell the age of the clam, as you observed in the fresh-water clams."

Having thus explained to us the functions of the shell, the Professor picked up a large shell from a pile lying near, carefully severed the two adductor muscles by cutting them close to the shell with a flat-

bladed knife, removed the left valve, and presented to our wondering gaze the animal which made the shell.

We saw that the shell was lined by a soft skin, called the mantle or pallium, which secreted the two valves. This formed a closed bag, with the siphons at one end and a round aperture at the other end through which the foot might be thrust.

Carefully cutting away the central transparent part of the mantle, the Professor laid bare the internal organs of the animal, and explained their functions to us in detail. The long siphon was seen to contain two canals and to be very elastic, as we had seen in the living animal, being capable of stretching out several times the length of the shell. The aperture was seen to be lined with hairs, or cilia, which keep up a constant motion in the living clam, creating an inward current, which brings food to the animal in the form of microscopic animals and plants.

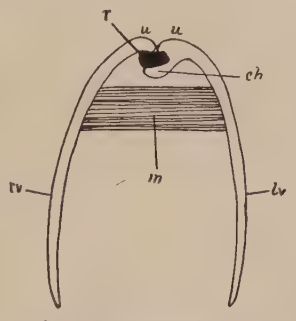


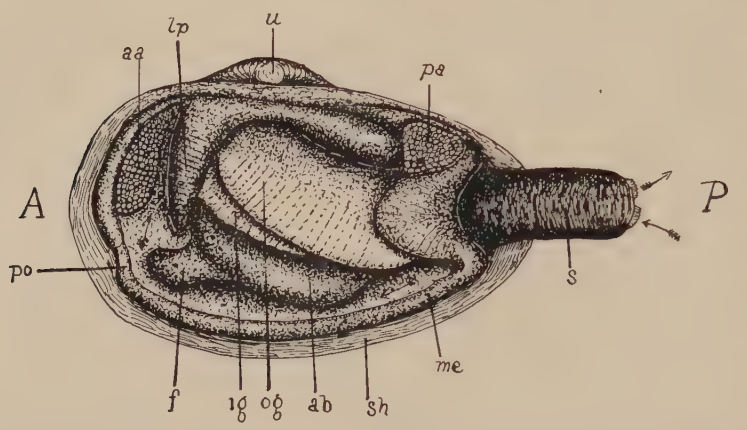
Diagram of a section of the soft-shelled clam, showing method of opening and closing the valves. ch, chondrophore, or shelly depression for the cartilage, or resilium, r; lv, left valve; rv, right valve; m, adductor muscle; u, umbo.

This class of mollusks, like the fresh-water clams, is headless, and the mouth leads directly to the stomach. Just back of the posterior adductor muscle, we were shown two pairs of delicate organs, suspended from the dorsal part of the animal, and called the labial palpi, or lips, which protect the mouth; and which, by the motion of the minute cilia on their surface, create a current of water toward the mouth. Lifting up the palpi we saw the little mouth lying between them. The most conspicuous objects were the two pairs of gills; one pair lying on either side of the fleshy abdomen. The gills were broad, wrinkled masses, hanging from the dorsal part of the animal to which they were attached. They were filled with many little tubes, through which the blood circulates, expelling its poisonous carbonic acid gas, and becoming laden with fresh oxygen.

"The gills not only purify the blood," said Professor Parker, "but they also aid in gathering the food. If examined with a powerful magnifying glass, the surface of the gills will be seen to be covered with thousands of little hair-like cilia all moving in unison like the oars of a man-of-war boat, thus keeping up a constant current. The little animals and plants which are brought in through the lower, or branchial siphon are caught upon the little cilia, rolled into a mucilaginous string, and passed on to the mouth, where they enter the stomach and intestine, and are digested. The nutritious portion is absorbed in the blood,

and the hard parts are cast out by the upper or cloacal siphon, as waste. The gills are, therefore, gatherers of food as well as purifiers of the blood."

Suspended between the gills we noticed a muscular body, which is the abdomen, with the small, spade-like foot attached to the lower end. This foot is capable of great expansion, and is thrust out through a round slit in the mantle, the edge of which is very muscular and much thickened.



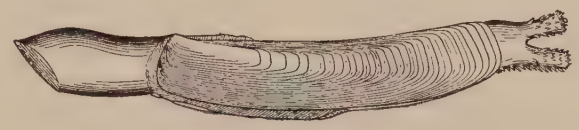
Soft-shelled clam, with left valve and a part of the mantle removed to show the principal organs of the animal. A, anterior end; P, posterior end; aa, anterior adductor muscle; ab, abdomen; f, foot; ig, inner gill; lp, labial palpi; me, mantle edge, which is much thickened; og, outer gill; pa, posterior adductor muscle; po, pedal orifice, through which the foot is extended; sh, shell; s, siphons; u, umbo. The arrows indicate the direction of the currents of water.

"Besides the organs already mentioned," continued the Professor, "the clam has a nervous system like that of the fresh-water clam, a brownish liver, and a heart and blood-vessels. The heart may be seen at the upper part of the animal, where the mantle is very thin, and is like that of the fresh-water clam. The foot is especially adapted for digging. When not in use, it is a small projection on the anterior end of the abdomen; but when extended ready for use, it is much swollen and greatly increases in size. The animal digs by pushing the foot into the sand, thereby making a hole, and pulling the foot after it."

We asked the Professor if it was true that the clams were becoming less numerous, and if so, why this was the case, as we had understood that each clam lays thousands of eggs annually. He said that it was true that the number was decreasing, and that this fact was due to several reasons; the first one being that they were gathered all the year round, and were not given time enough in one year to make up for the loss of the previous year. "And while it is true," he added, "that each clam produces hundreds of thousands of eggs, yet they are so beset with enemies that but a comparatively small number reach maturity. The eggs are deposited during September and October, and some of them are soon eaten by other animals. After the little clams hatch, they swim about in the water for a time, and finally sink to the

bottom and dig burrows, as do their parents. During this free-swimming time they are the prey of numerous animals — mollusks, worms, starfish, and even fishes — so that only a small number live to become established in their burrows. They should be protected during the months of September, October, and November, in the same manner as are the birds in the spring. Not only is the clam in great danger while young, but even when it has reached adult life and is apparently safe in its burrow, it is still beset by enemies. One of these is the clam worm, a cylindrical animal about an inch long, and the other is the drill, which sometimes finds the clam near the surface, and then proceeds to drill a hole in its shell and suck the juices of the animal. Flounders, cod, and other fish also prey upon the poor clam."

As the tide was now almost high, we picked up our collecting baskets and walked toward the boat landing. On our way, one of our party picked up a long, slim clam, resembling the blade of a razor. This, the Professor said, was called a razor clam. A little later, another specimen was found which contained the animal. It was very curious, and is pictured on this page. The siphons were partly divided, and covered with little finger-like projections called papillæ. The foot was very sharp and somewhat pointed on the end.



Razor shell, Ensis directus, with foot and siphons extended. (Verrill.)

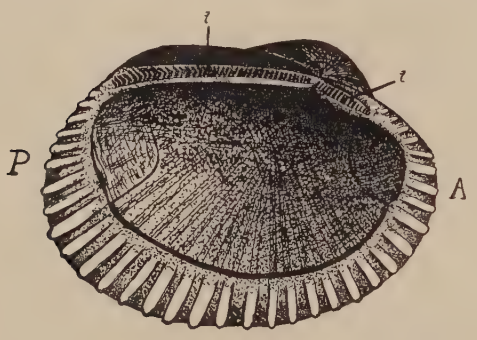
Near the razor clam, the Professor picked up another shell containing the animal which he called *Tagelus gibbus*. The foot was very large for the size of the shell, and the siphons were remarkable, being very long, and separated their whole length. Professor Parker told us that the siphons of different bivalves were of many shapes and sizes. Some, like the soft-shelled clam, were long, and bound up in one piece. Others, like the *Tagelus*, were long and separated; while still others were short, thick, united, or separated; and in fact, almost any modification could be found. In some cases, one siphon might be longer than the other, as is the case

Tagelus gibbus, with foot and siphons extended. Note the long, divided siphons. (Verrill.)

with some tellen shells. We were each fortunate enough to find a specimen of the *Tagelus*.

Just before reaching the steamer, we walked along a ridge of land a little above high tide, which was literally packed with the shells of different kinds of mollusks. Here were clams, oysters, scallops, drills, heart shells, moon shells, slipper shells, and a host of others. Among these were a number of heavy, rounded shells, which the Professor called quahogs. One of these was alive, and we saw that it had a large foot, and two short, thick siphons. The hinge differed very much from that of the soft-shelled clam, and was very much like that of the fresh-water clam, excepting that it was much broader, and the lateral teeth were heavier. The anterior part of the shell also showed a plainly marked lunule.

All were particularly interested in the ark shells, with their heavy, radiating ribs, and their peculiar hinge, which bore about forty little teeth in each valve. The Professor reminded us that we had now seen three types of hinges; the clam, without pronounced teeth; the ark, with many small teeth, and the fresh-water clam and quahog, with well-marked cardinal and lateral teeth.



Interior of ark shell, Arca pexata, showing the large number of teeth, t, forming the hinge.

Our ride home was one never to be forgotten. It was twilight when the steamer left the wharf, and as we steamed slowly up the bay the darkness deepened, the beautiful tints of the western sky faded slowly away, and night settled over us like a huge curtain. Along the shore, the lights in the cottages began to appear, and in a little while the full moon rose and cast its beams over the dancing waves. An hour later, we landed at Providence, tired and hungry, but filled with the satisfaction that only the born naturalist can experience after a day of successful collecting and communion with Nature.

FROM COL. CHI. ACAD. SCIENCES.

THE OYSTER AND ITS RELATIVES.

COPYRIGHT 1901, BY A. W. MUMFORD, CHICAGO.

Cytherea lupinaria (Panama).
Ostrea lacerans (Bahamas).
Pecten dislocatus (Florida).
Pteria radiata (Florida).

Spondylus imperialis (China).

Ampsilis luteola (U. S.)
Mytilus edulis (U. S.)
Cardium isocardia (Florida).
Tellina radiata (Florida).

THE OYSTER AND ITS RELATIVES

Several days after our trip down the bay, Professor Parker invited us to go to Boston with him and visit one of the museums of that city, where we might together study some of the different varieties of bivalve mollusks. We accordingly took an early train, which carried us to Boston in a little over an hour.

Without delay he conducted us to the museum, which was situated but a short distance from the station. We entered the square, massive building, passed by numerous cases filled with minerals and geological specimens, and ascended to the first gallery, where the mollusks were located. The shells filled the cases in several rooms, and to one of these the Professor led us. In this case were some of the most beautiful shells we had ever seen.

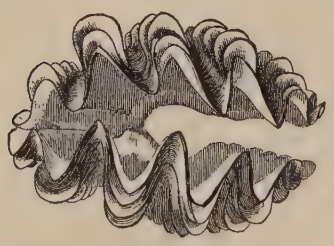
"The clams, oysters, and mussels belong to the class *Pelecypoda*," said Professor Parker, "which is the lowest, or rather the simplest, of the branch of animals which we call the *Mollusca*. As you have already learned, the animal is encased between two shelly valves made of carbonate of lime. Some of the bivalves live in the mud, in various positions, and are able to move from place to place at will. Others, like the oyster, live attached to some object at the bottom of the sea, such as a stone, a piece of wood, or the piling of an old wharf, and are not able to travel about as are their more fortunate relatives, the quahog and the clam. Still other bivalves attach themselves by a byssus composed of silk-like threads, which anchor their shells to stones, sticks, and other foreign objects.

"The shells in the case before us are among the most attractive of the bivalves. They belong to the family *Veneridæ*, or Venus shells; and the little, shelly skeleton is ornamented by many bright colors, the patterns occurring in spots, dashes, zigzag lines, and rays. Some varieties, such as the spiny Venus, *Cythera lupinaria*, have the posterior end of the shell armed with long, sharp, curved spines, and the shell is also frilled in a beautiful manner. The common quahog, or round clam, which you found so plentifully on our excursion to Rocky Point, is a prominent member of this family on account of its value as an article of food along the whole Atlantic coast, where it is much esteemed.

This family comprises about five hundred species, which are distributed throughout the whole world, and are found ranging from between tides, to several hundred fathoms beneath the surface of the water.

"The family *Cardiidæ*, the heart-shells, or cockles, comprise some of the largest and most attractive of *Pelecypods*. The name *Cardium*, signifying a heart, is given to them because of the close resemblance to that organ when the shell is viewed from the anterior end. These animals live in sandy or muddy bays, and generally congregate in thousands. In England, the edible cockle, *Cardium edule*, is considered quite a delicacy, and annually, thousands are used for food. In our own country they are not generally eaten, except by the poor in Florida and in some places along the Gulf of Mexico. The waters of Florida furnish some very handsome species, among them the rich, red *Cardium isocardia*, and the large *Cardium magnum*, the latter attaining a length of five inches, and being ornamented by beautiful color patterns of brown and yellow. The foot of the *Cardium* is very peculiar, being shaped like a sickle, which enables the animal to pull itself along at a lively gait. A California cockle, *Liocardium elatum*, grows to a diameter of seven inches, and would furnish a meal for several people. Members of the *Cardium* family are found in all parts of the world, from the Arctic regions to the Tropics, and they number several hundred species.

"In the family *Tridacnidæ*, which we find in this case, size seems to have reached its limit. This specimen of *Tridacna gigas*, which is so nicely mounted, lives in the Indian Ocean, grows to a length of nearly six feet, and weighs as much as eight hundred pounds. It is recorded that a pair of these shells, which are two feet in diameter, and weigh five hundred pounds, are used as benetiers in the church of St. Sulpice, Paris. In some parts of the Indian Ocean, where pearl and sponge fishing are carried on, this clam, which is known as the giant clam, is a source of great danger to the divers, many losing their lives by having either hands or feet caught between the great valves of the shell. Many a diver has amputated a finger, hand, or foot, and thus saved his life at the expense of one or more of these members.



Tridacna squamosa. A relative of the giant clam of the Pacific Ocean. (Woodward.)

"Let us now give our attention to this case of tellen shells," continued the Professor. "This family, the *Tellinidæ*, numbers among its five hundred or more species some of the most beautiful of the bivalves. What could be handsomer than this tablet of specimens of the sunrise

tellen, *Tellina radiata*, which is so plentiful along the shores of Florida and the West Indies? You notice that the right valve looks not unlike the horizon at sunrise, the brilliant rays of color spreading in different directions from a common center. The various species of the family live buried in the sand or sandy mud, and are found throughout the world. The siphons of the tellen are very long and are separated, the upper one being half or three-quarters as long as the lower one. The foot is rather long and pointed, and admirably adapted for burrowing. The long siphons enable the animal to bury itself to quite a depth below the surface of the sand. At Newport, I have gathered many hundred specimens of this beautiful little pink tellen, *Tellina tenera;* the shell of which you see is tinted a delicate pink or pinkish white.

Gari vespertina. An English tellen shell. Note the two long, separated siphons. (Tryon.)

"Placed beside these tellen shells you will note another and related family, the *Psammobiidæ*, which contains some very pretty and interesting shells. I purchased a book yesterday on the shells of the Pacific Coast of the United States, entitled 'West Coast Shells,' written by a California gentleman, Professor Josiah Keep." The Professor drew a small volume from his pocket, and said, "If you will turn to page 199, you will find an excellent description of one of these animals, called *Psammobia rubroradiata*, or the red-streaked *Psammobia*." Harry took the book, turned to the page indicated, and read as follows:

"'But I wanted to see more of him, so I took a large jar, filled it half full of beach sand, added as much sea-water as it would hold, and plunged my prize into the same. He rested quietly for a few minutes, and then began to open his shell and cautiously put out his two siphons. Soon afterward, from between the two edges of his shells, came his big, white, spade-shaped foot. He drove it down into the sand, curved it a little to one side, gave a vigorous pull, and, lo! his shell followed, though just why, I could not clearly understand. Though the jar was large, he reached the bottom before his shell was wholly covered with sand, and had to content himself with a half-above-ground tenement. Next morning his siphons were stretched out some six inches in length. I never thought before that there was any particular beauty to the siphons of a clam, but for this red-lined one my opinion quickly changed. Imagine two tubes made of the finest pink and white silk, stretched over delicate hoops arranged at regular intervals; then think of them as endowed with life, and waving with a graceful motion through the water, and you will have a faint idea of their exquisite texture and

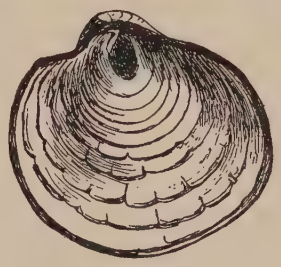
elegant appearance.'" We all thought that this description was very vivid, and that it gave us a good idea of the appearance of this interesting animal.

Passing by several minor families of shells, Professor Parker conducted us to a series of cases which contained a large collection of *Unionidæ*, or river mussels. These, he said, were no less interesting than the marine shells which we had seen, and in many instances they excelled their salt-water relatives in beauty of ornamentation. The general colors were black and shades of green, and their surfaces were variously marked with knobs, spines, and rib-like undulations, with rays and spots of color. The tints of their interiors were most beautiful, ranging from pure, silvery white, through orange, pink, and salmon, to dark purple; and the rich, pearly iridescence rivaled that of any of the marine shells. These reminded us of a collection, which we had seen in the West, illustrating the pearl-button industry, and from which we learned that hundreds of tons of these shells are gathered yearly from the Mississippi River and sold to the button factories at Muscatine and other places in Iowa, for the purpose of manufacturing pearl buttons. We learned from Professor Parker that the Mississippi Valley is the metropolis of this family, and that more species are found there than in all the rest of the world combined. He also told us that there are about one thousand different kinds of these mussels. "Pearls," he added, "are found in river mussels, but are usually of little value, although some very valuable ones have been found.

"The shell that is the most familiar to many people is the oyster, *Ostrea virginica*, and in the case next to those containing the river mussels, we may see a variety of these and their near relatives," continued Professor Parker, walking toward a case some distance away. "The cultivation of this bivalve occupies the attention of a large number of men, and the investment of considerable capital. The oyster is free and active when young, but becomes attached to some submerged object early in life. Oyster culturists take advantage of this habit by erecting poles in the water to which the young oysters attach themselves. One valve, the lower one, becomes attached, and the oyster spends its life in this condition, with neither foot nor siphon, and entirely dependent upon the currents in the surrounding water for its food, which consists of the larvæ of sponges and mollusks, and of various species of microscopic animals. The oyster has many enemies, chief among which is a species of boring sponge, which eats into the valves to such an extent that it falls to pieces. Another enemy is the drill, which bores a hole in the shell and sucks the juices of the animal through

this aperture. It is said that the young oyster has but one chance out of one million, one hundred and forty-five thousand, to survive and reach adult life, so numerous are the destructive agencies which surround it. To offset this terrible mortality, each oyster lays several million eggs in order that a few may survive to perpetuate the species. Oysters are found in many parts of the world, and the different species vary much in their form and in their mode of life. In the 'cock's comb' both of the valves are curiously plaited, while another species, the 'tree oyster,' grows on the roots of the mangrove. The common edible oyster sometimes attains the length of a foot, while a Japanese species, *Ostrea talienwaniensis*, reaches the astounding size of three feet.

"Distantly related to the oysters is the *Anomia*, or jingle-shell, which attaches itself by a huge plug or byssus to other objects. This plug passes through a hole, or foramen, in the lower valve, and so tightly does it hold the *Anomia* to the object upon which it is resting, that its shell becomes molded to the surface of that object. You will note several specimens in this case which are attached to the shell of the scallop, the *Anomia* having its shell ribbed in precisely the same form as the scallop. In France, this animal is used as an article of food.



Anomia simplex, one of the "jingle-shells." The orifice through which the byssal plug is thrust is shown in the upper part of the figure. (Tryon.)

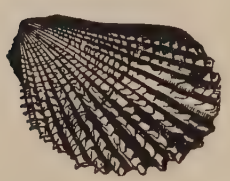
"You have no doubt heard of the 'dancing scallop,' and here you may see nearly a hundred different kinds. This family, the *Pectinidæ*, is composed of rounded shells, many with frills or ribs, and nearly all ornamented with beautiful colors. Here is one from China, for example, with one valve white and the other reddish brown streaked with white. Unlike the quahog and clam, these animals have no siphon, and the shell is open all the way around save at the hinge. The edge of the mantle is provided with small, round, black eyes. With its foot, the animal spins a byssus, which it extends through a little notch on one ear of the shell near the hinge, and with which it attaches its shell to pieces of seaweed, bits of wood, and other objects. A beach at low water is an interesting place, the receding tide having left on the shore, or in little pools, hundreds of these mollusks, attached by the byssus to pieces of seaweed. As one stands gazing wonderingly over the vast fields of yellow sand and green weed, an object will suddenly move through a pool of water with astonishing rapidity, accompanying the movement by a quick, snapping sound. This is the scallop, which is imprisoned in the pool and desires to get out. The movement is effected by rapidly

opening and closing the two valves of the shell, thereby causing a clicking sound. The noise of several hundred of these clicking shells, and the sight of as many of them with strings of seaweed attached to them, looking not unlike a comet with a long tail, is quite bewildering. This habit of shooting through the water has caused them to be called 'dancing scallops.' In both Europe and America the scallop is considered a delicacy, and several tons are gathered annually. The scallop, *Pecten maximus*, has a bright orange body and a fawn-colored mantle. A related species, *Pecten jacobæus*, has been dignified as a badge of several orders of knighthood, and it was also worn by pilgrims to the Holy Land, many years ago. It was called St. James's Shell.

"The family *Spondylidæ* is closely related to the scallops, and the shells certainly rank as among the most beautiful and striking of all bivalves. They are variously colored with brown, red, and white, and are covered with many long, graceful, sharp spines. In some species, in adult life, the lower valve is attached like the oyster, from which habit they have received the common name of 'spiny' or 'thorn' oyster; but a few, like the *Spondylus imperialis*, in the center of this case, remain free during life. The finest and largest specimens come from the Gulf of California.

"A family closely related to the *Spondylidæ* is the *Limidæ*, of which the genus *Lima* is the typical form. The name *Lima* means a file, and the shells are called 'file shells,' because the surface is covered with scaly ribs, giving it the aspect of a file. There are about twenty species in the family, which are found in many parts of the world. In early geological times they must have been very numerous, over three hundred species having been found in the rocks of Europe, India, and the United States.

"Dr. J. Gwyn Jeffreys, in his 'British Conchology,' thus writes of the *Lima:* 'The *Lima* moves, or rather darts through the water like a scallop, but in a contrary posture. The hinder, instead of the ventral end is in front, so that the mode of its progression may be compared to that of a fish swimming tail foremost. Some species construct dwelling-places called 'nests' out of fragments of shell, coral, gravel, and other material, which they ingeniously fasten together by their byssal threads and attach to the roots of large seaweeds. Several young ones often occupy the same nest, or case, but when they become adult each individual has a house of its own. This remarkable construction is funnel-shaped, with the larger end contracted, and sufficiently wide to admit



Lima squamosa, a common Chinese file-shell. (Tryon.)

of the *Lima* moving freely up and down, but not turning around in it. Here it lives secure from prowling fish and crabs. The case is lined inside with a closely woven net of byssal threads, plastered over with slime. When the *Lima* is first taken out of its case and put into a basin of sea-water, it is exceedingly active and restless, or else it gracefully careens about, with its long and thick fringe of filaments trailing behind it. In the course of a few minutes it seems to get tired, or reconciled to its prison; and it then lies on its back, the valves of its shell expanded, and reposes on its own soft, luxurious cushion. The filaments (or tentacles) at first curl and entwine around one another, but afterwards they are withdrawn and become contracted; a circular, inner row, like a coronet, surrounds the slowly flapping gills; and the outer rows fold over on each side and form a sort of *chevaux-de-frise*. A remarkable peculiarity of *Lima* consists in the tenacious grasp of its tentacles; sometimes when my finger touched the animal, it was rapidly seized by the tentacles, as by those of an *Actinia* (or sea anemone), and so firmly, that I have dragged the *Lima* around the tank. It seldom let go its hold until the tentacles were torn away, or as I believe, voluntarily thrown off by the animal. The tentacles so detached still adhere closely to the object they have grasped, their free ends twisting about as if conscious of life, and they are with difficulty taken off.'

"One of the larger bivalves belongs to the family *Pinnidæ*, comprising the wing shells of which, one species, *Pinna nobilis*, attains a length of two feet, and spins a fine, silken byssus by which it moors its shell to some solid object. They frequently bury themselves almost from sight in the sand, the shell standing erect with knife-like edges. The Italians gather the byssus of this species and weave it with silk, from which they manufacture gowns, caps, and other articles of wearing apparel. You may see some of these articles in this case. The shells of *Pinna* are triangular in shape, very thin and brittle, and the hinge is without teeth of any kind. The wing shells entertain a guest in the form of a little crab, which lives in the mantle and gills without any apparent discomfort to the animal. Many hundred years ago, Aristotle, the Greek philosopher, gave it the name of *Pinnotheres*, or Pinna-guardian, he having believed that the crab had formed an alliance with the *Pinna*.

"The family *Pteriidæ*, comprising the 'pearl-oysters,' is of great interest, both scientifically and economically. At the present time there are a little over one hundred species living; but the family has existed since early geological times, and over a thousand species have

been found in the rocks. The shells of this family are very broadly rounded, and the hinge line is long and straight. The thickness of the animal is small compared to its breadth. The pearl oyster, *Meleagrina margaritifera*, is the most important member of the family, furnishing, as it does, the beautiful pearls of commerce. These animals are found at Madagascar, Ceylon, and other parts of the Indian Ocean. The pearls are formed by some irritating substance, as a grain of sand, some parasite, or even an egg getting in between the shell and the animal, or lodging in some soft part, which causes the animal to cover it with pearly matter to prevent irritation. Pearl gathering, by diving, has been carried on at Ceylon since the time of Pliny, and several remarkable pearls have been found. The largest pearl known, that of Mr. Hope, weighed eighteen thousand grains, and measured two inches in length and about four inches in circumference. The Chinese produce artificial pearls, as well as pearl images, by inserting a lead figure, or small, round object between the mantle and the shell, which the animal covers with pearl in a few months. The shells of the pearl oyster furnish the larger part of the mother-of-pearl, which is so largely used for ornamental purposes, and several hundred tons are imported into England annually, principally from Manila. A species of pearl oyster lives at Panama, and a related species, *Pteria radiata*, in Florida and the West Indies.

Malleus vulgaris, the "hammer-head oyster" of the Indian Ocean. A near relative of the pearl oyster. (Tryon.)

"You will probably remember," said Professor Parker, stepping over to another case, "the large bank of mussel shells which you saw on our trip to the beach at Rocky Point. In this case are exhibited a large variety of these shells. Notice the peculiar, wedge-shaped shell, with its small, rounded anterior end, and broad, sharp posterior end. Note also the little bunch of thread-like filaments which extend from near the anterior end of the shell, and fastens that large specimen to a stone. That is the byssus, which is spun by the foot of the animal, and by which they attach themselves to mud banks and vegetation. The huge banks of these mussels, some of which have black, glossy shells, are familiar objects to the seaside visitor. At low water they are among the most conspicuous objects on the shore. A related genus, *Modiola*, burrows in the ground or spins a nest formed of stones

and fragments of shells, the byssal threads holding them together. One species varies from this rule, and simply spins a byssus. This is the *Modiola plicatula*, a yellowish shell found on the Atlantic coast of the United States. This *Modiola* uses its foot like a snail, and has been seen to crawl up the side of a glass jar.

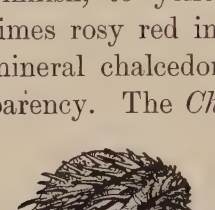
"The mussels are of great importance and value economically, thousands of bushels of the edible mussel, *Mytilus edulis*, being consumed annually in Europe. They are also used as bait, millions being taken for this purpose. An ingenious method of fishing for mussels is used at Kiel, Germany. Boughs of trees are placed in the Bay of Kiel and allowed to remain for three, four, or five years, at the end of which time they are covered with mussels. Between December and March they are taken up and sold by weight. The mussels are said to attain their growth in a single year.

"Still another interesting mussel is the date shell, or *Lithodomus*, so called from its habit of boring a 'stone house' in corals, or even in the hardest limestone rock. Its burrows are shaped like the shell, which prevents it from turning around. They are like the mussels in form, and are considered a delicacy by some of the inhabitants of the shore of the Mediterranean Sea. The perforations which this animal has made in the Temple of Serapis at Puteoli have shown that the sea-coast has materially changed in modern times.

"We must now hurry on, and pass hastily by several cases which we cannot study to-day. Here in this case is a large collection of ark shells, with their peculiar multidentate hinge. They live at low water, under and about stones, to which they anchor themselves by a byssus. In the same case are a number of the nut shells, *Nucula*, and a related genus, *Yoldia*, the shells of which are smooth and polished. These animals live in large quantities in bays and in the mouths of rivers, buried in soft mud. We must also pass by the *Astartes*, with their brown and chestnut shells, many of which are plaited like a lady's skirt.

"We will pause a moment, however, and study the handsome shells of the family *Lucinidæ*, which embraces about one hundred and fifty species of rather solid, whitish shells, beautifully ornamented with fine lattice work, or straight radiating ribs. The species of this family dwell principally in temperate and tropical seas, and love muddy and sandy bottoms. They have been found from low water to very great depths. The foot of the principal genus (*Lucina*) is hollow; is frequently twice as long as the shell, and is folded back upon itself and hidden between the gills. Several handsome species of *Lucina* inhabit the shores of Florida, notably *Lucina tigrina* and *Lucina chrysostoma*."

At this point George interrupted Professor Parker by asking hi if a certain family of shells in the same case were oysters. Their shel were very irregular, and were attached to each other and to variou objects in the same manner as the familiar edible bivalve. "No, answered the Professor, "these are not oysters, although they some what resemble them. They are members of the family *Chamida* which live in the vicinity of coral reefs in the tropical seas of man parts of the world, and are attached by either valve to some objec Their shells are variously sculptured, some being ribbed, while othe are foliated or spinose. In color they vary from pure white, throug pinkish, to yellow. A California species, *Chama pellucida*, is some times rosy red in color, and a perfect specimen is translucent like th mineral chalcedony. It receives the name of *pellucida* from its tran parency. The *Chamas* of Florida are very handsome shells, *Chama arc nella* being covered with straight spines, whil *Chama macrophylla* is beautifully frilled. Th name of the genus was first given to it by th naturalist Pliny and revived by Linnæus."



Chama arcinella, a common Florida bivalve. (Tryon.)

Placed near the *Chama* family was a collectio of the fresh-water shells belonging to the gener *Sphærium* and *Pisidium*, the latter being so sma that we could scarcely see them. Near these w saw several species of the *Cyrenas*, which live i the brackish waters of warm countries, buried in the mud.

"This family," continued Professor Parker, pointing to a grou of shells with brilliantly polished surfaces, "comprises the wedge-shell or *Donax*. On the shores of Florida and California they may be foun by thousands buried an inch or two beneat the surface of the sand. The foot is larg and pointed, and particularly adapted fo burrowing.

Spisula solidissima, a common hen-clam of the Atlantic coast of the United States. (Tryon.)

"I am sure you will be interested in th chicken, or hen-clams (*Mactra*) of whic a number of species may be seen in thi case. This is a large family, which is repre sented in all parts of the world, and em braces some one hundred and fifty or mor species. On the Atlantic coast of the Unite States, a species called *Spisula solidissim* attains a length of about six inches. They bury themselves just beneath the surface of sandy shores. The long, finger-like foot is used for leap

FROM COL. CHI. ACAD SCIENCES.

519

SOME SNAILS OF THE OCEAN.

COPYRIGHT 1902, BY A. W. MUMFORD, CHICAGO.

Cerithium aluco (East Indies).
Turbo petholatus (Indian Ocean).
Harpa nobilis (Philippines).

Haliotis assimilis (California).
Terebra lamarckii (Sandwich Islands).
Fissuridea listeri (U. S.)
Crepidula fornicata (U. S.)
Littorina angulifera (U. S.)
Bulla ampulla (Philippines).

Mitra pontificalis (Indian Ocean).
Nerita peloronta (Florida).
Strombus auris-dianae (Philippines).

ing. In some places this shell is used as food for swine and other animals, and it is said to be preyed upon by starfishes as well as by gastropod mollusks."

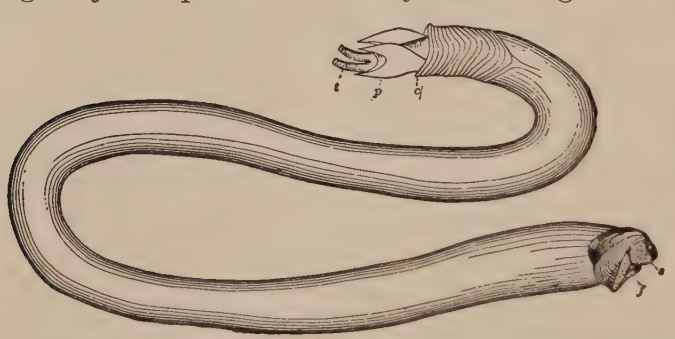
While Professor Parker was telling us about the *Donax* and *Mactra*, George had walked ahead, and we suddenly heard him call to us. "Come over here," said he, "here is a whole case of razor clams, and some of them are very large!" We hastened to his side, the Professor smiling at his enthusiasm. "Yes," said the Professor, "these are the razor clams, or 'spout fishes,' so called from their habit of spouting water when disturbed. There are about thirty-five species in this family, living in all seas except the Arctic. They burrow in the sand, at extreme low water mark, at an angle of about sixty degrees. They are said never to voluntarily leave their burrows, and if removed will instantly bury themselves again. They are great diggers, and the collector must indeed be agile who can catch one of these creatures when it once starts to bury itself deeper in the sand. This clam is said to be an excellent article of food when cooked, and the fishermen of Naples have a unique method of catching it. They wade out to where the water is shallow, and feel for the *Solen* with the foot. When the clam is felt, it is caught between the great toe and the next one and fished up. Frequently the fishermen's feet are badly lacerated (although protected by linen bands) by the sharp shell of the *Solen* in its frantic efforts to bury itself out of harm's way. It has been known to bury itself to a depth of three feet below the surface.

Ensis directus, a razor shell which lives on the eastern shores of the United States. (Dall.)

"We must not forget to see the different kinds of clams, since we gathered such a nice lot of the soft-shelled ones on our last excursion. There are not many species of the genus *Mya*, and they are rather small, and confined to northern seas. It is said that the large walrus feeds entirely upon clams, and various species of crabs love the esculent bivalves. A related genus contains some large species, the most notable being the Washington clam, *Tresus nuttallii*, whose shell is ten inches long, and whose siphon reaches the astounding length of two feet, and is of correspondingly large diameter. This clam inhabits the western coast of the United

States, and buries itself two feet below the surface of the mud, keeping its communication with the water above by means of its long siphon. A large specimen is exhibited in this case with the siphons extended and stuffed in their natural position. The clam of the Atlantic coast has been introduced on the Pacific coast, and it is said to be slowly crowding out some of the native species of bivalves.

"We must now pass on, and hastily glance at the two remaining families in this case, for it will soon be closing time, when we must leave the building. This family comprises the 'angel wings,' or 'piddock' shells. They are all borers in mud, clay, wood, and granite, although their shells are thin and fragile. It is not definitely known how this boring is done, some scientists claiming that it is by means of an acid solvent secreted by the animal, while others believe the shell or foot to be the means employed. However this may be, the mollusk and its burrow are of great interest, and worthy of much study. The holes are mostly vertical and quite symmetrical, quite closely fitting the form of the shell. On the coast of Devon, England, the piddock, *Pholas dactylus*, is used for bait. In many places a large number of people are employed gathering this mollusk, not only for bait but for food. It is eaten well seasoned and cooked with bread crumbs. The common 'angel wing' of Florida is sold for food in the markets of Havana, Cuba. The shell is curious for having two accessory, spoon-shaped pieces, just beneath the umbones, which act as supports for the liver of the animal. In addition to these accessory pieces of shell the skin of the *Pholas* is rendered more solid and rigid by the presence of many siliceous granules. It is said that the California piddock, *Parapholas californica*, utilizes the dust made by excavating its burrow in building up a strong tube to protect its siphons. The *Pholas* emits a peculiar phosphorescent light when alive, and this phosphorescence clings to it even after death. Some pelagic mollusks also possess this phosphorescence.



Animal of Teredo navalis. c, collar; f, foot; p, pallets; s, shell; t, tentacles. Note the long, worm-like body of the animal. (Verrill.)

"The ship worm, *Teredo navalis*, is another borer which does an

immense amount of damage. This animal measures a foot in length, although it sometimes attains a length of three feet. The shells are two little hemispherical valves placed at the extreme posterior end of the body. The siphons are very long and worm-like, and terminate in two shelly pallets or paddles. The foot is broad and sucker-like. The vital organs of the animal are all encased in the little shell. The *Teredo* bores into wood, such as piling, wharves, ships, and any kind of timber, and no wood is hard enough to withstand its ravages. It always bores in the direction of the grain unless it meets another *Teredo* or a knot in the wood, when it will change its course a little. As it bores, it lines the tube with shelly matter, always keeping the tip of its siphons within easy reach of the original opening, in order to obtain both a food supply and oxygen. The wood which is swallowed in boring the tunnel is taken into the mouth, passes through the stomach and intestine, and is expelled into the water. When the *Teredo* first enters the wood the hole is very small, and for this reason a piece of wood may be perfectly honeycombed with the tubes of this animal, and the fact may not be known until some shock or blow breaks the timber and reveals the damage. Metal sheathing and broad-headed nails have been found very effectual in protecting ships and piers from the *Teredo*. The curious pallets spoken of are used by the animal to effectually close its tube when danger is near, or when it desires to shut off the current of water.

Watering-pot shell, Aspergillum vaginiferum. a, original valves of shell; b, sieve-like lower end, with row of tubes; c, frilled upper end. One-half natural size. (Woodward.)

"One of the most curious of bivalves is the *Aspergillum*, known as the watering-pot, which burrows by hundreds in soft mud. The original shell is about a quarter of an inch in length; but the adult animal is encased in a large, shelly tube fully seven inches long, in the lower end of which the scarcely distinguishable valves are cemented. The lower end is perforated by many small, tube-like holes, and the upper, or siphonal, end is encircled by four or five frills, or ruffles. There are about twenty species in this peculiar genus, living in the Red Sea, at Java, Australia, and New Zealand, and the mollusk is certainly very strange and shows to what extremes Nature goes in fashioning her creatures."

As it was now closing time, we left the building, and in about an hour took the train for Providence.

THE ROCKY HOME OF THE DRILL AND PERIWINKLE

Photograph by F. M. Woodruff

IN SEARCH OF THE DRILL AND PERIWINKLE

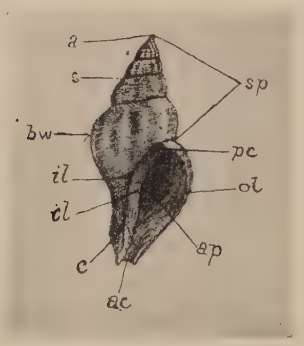
> And should the strongest arm endeavor
> The limpet from its rock to sever,
> 'Tis seen its loved support to clasp,
> With such tenacity of grasp,
> We wonder that such strength should dwell
> In such a small and simple shell.
>
> — WORDSWORTH.

Not long after our trip to Boston, we again visited the shores of the bay, this time near the little town of Apponaug. Here the shore was covered with rock and various kinds of ocean debris. The beach was muddy and sandy in places, and the water was shallow for a long distance into the bay. A fresh, sea-born breeze was fortunately blowing, tempering the otherwise torrid heat of a July sun. Alighting from the train which had brought us from Providence, we crossed a bridge spanning a small creek, and descending a steep bank, within a few minutes we were at the shore. The tide was at its lowest ebb, and stretching out before us was a wide expanse of mud-flat, with tiny pools here and there, which were inhabited by many of Nature's strange creatures. Far out over this stretch of muddy beach the tide was slowly coming in; the waves were rolling angrily, but becoming calm and peaceful as they struck the shelving beach, they glided toward us with a soft murmur.

We walked along the shore, passed numerous groups of men and women who were digging clams, and then started across a broad expanse of beach toward a little creek which flowed into the bay. As we hastened along, little jets of water spouted up on every hand, revealing the presence of soft-shelled clams. Crossing the mouth of the creek, which at low water was but a few inches in depth, we soon came to a pile of rocks, and a small pier which extended into the water to where the depth was considerable. Here the rock-loving sea snails were very abundant, and the old pier was fairly alive with specimens of the drill, a common snail along the coast from Maine to Florida.

A large-sized individual of the drill measures over an inch in length,

and is fusiform, or spindle-shaped; that is, it is larger in the middle than at either end, where it tapers to a point. Professor Parker suggested that we examine the shell of this species, and see how it compared with that of the fresh-water snails. This we did, and found that every part of the latter could be found in the former. Here were the rounded whorls revolving round the imaginary central axis, the oval aperture, the inner and the outer lip, the columella, the suture and the umbilicus. We noticed that this shell was roughened by many spiral lines which encircled the whorls. In addition to these spiral lines were many fine lines parallel with the edge of the outer lip and shaped like it. These were the lines of growth, showing where the animal had added new matter to its shell. Crossing the shell at right angles to the spiral lines, there were about twelve rounded ridges. These represented the periods when the animal ceased adding to the outer lip of the shell, and built this ridge or varix. The Professor told us that some snails, like the drill, build several of these ridges in a single year; but that others, as the rock shells (*Murex*), build but three or four, and these are highly ornamented, with frills and folds. The aperture of the drill was tinted a dark purple, and was very narrow at the lower end, and formed a little canal through which the siphon was thrust. We learned that very frequently there were two canals, one at each end of the aperture, called respectively the anterior and posterior canals. "It is a curious fact," said Professor Parker, "that in most of those shells having a canal in connection with the aperture, the animal is carnivorous, and lives by preying upon other animals, as does the lion and the tiger, while in those shells with a rounded aperture, the animal generally subsists upon vegetable food.



Shell of the drill, Urosalpinx cinereus, showing the different parts of the shell. a, apex; ac, anterior canal; ap, aperture; bw, body whorl; c, umbilicus; cl, columella; il, inner lip; ol, outer lip; pc, posterior canal; s, suture; sp, spire. (Binney's Gould.)

"The mantle of the drill," continued the Professor, "as indeed of other snails, is a closed sac which communicates with the water by means of one or two siphons. The anterior siphon, which is extended through the long anterior canal, is rather long and is generally reflected, or turned back toward the shell. In some genera of snails there is a posterior siphon of greater or lesser length, which extends through the posterior canal, and expels the water from the gills in addition to the waste matter from the intestine. In a few snails, as *Cypræa* and *Ovula*, the posterior canal, instead of being a mere notch, as in the drill, is extended in the form of a tubu-

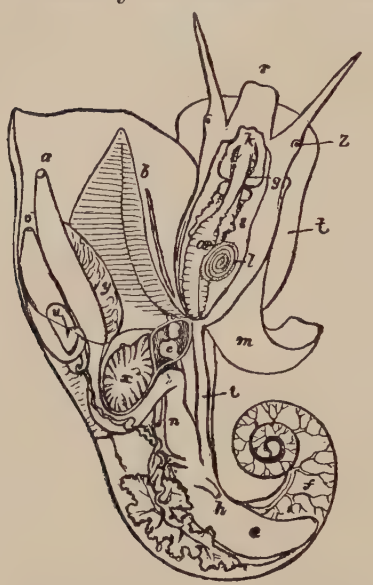
lar canal. It will be seen after examining our drill, that it is typical of the great class of mollusks which inhabit the sea, and are called *Gastropods* because the foot or organ of locomotion is on the lower side of the body, and the animal apparently crawls upon its stomach. The name *Gastropod* is from the Greek and means stomach-footed. In some marine shells the spire is long and tapering, in others it is short and blunt, while in still others it is almost flat. The shells also vary, some being fusiform, others cone-shaped, ovate, ladder-like, or ear-shaped; in fact, the variety in form is almost endless. But however the shell may vary, it can be described by the names which we have given to the different parts of the drill."

Having examined the shell of the drill, we turned our attention to its occupant, the animal. This was not unlike those we had already studied which lived in fresh water. Here were the same foot, tentacles, head, rostrum, eyes, and operculum that we saw in the apple snail, only they were of different color and shape.

Professor Parker now led us along the shore to a place where several large pools had been left by the receding tide. "Let us peer into the water of this pool," said he, "and see if we can find a drill about its daily work in its native home." As we gazed through the clear water, we saw many beautifully colored seaweeds — green, red, yellow, and brown — and darting here and there were several minnows, alarmed at our close proximity. On the bottom of the pool, beneath a shelving rock, were several "five-fingers," or starfish, while in another nook was a clam-worm, with its hundreds of legs moving about. On the under side of the overhanging rock, several sea anemones, those flowers of the ocean, were seen, with their tentacles expanded, ready to catch some unwary fish with which to fill their capacious stomachs. Crabs, snails, and clams made up the rest of the inhabitants of this miniature world.

On the rock beside the sea anemones, we saw a drill, and hastily putting his hand in the water, Harry drew it from the rock. But alas, as his awkward hand grasped the shell and disturbed the waters of this quiet pool, what a change took place! The sea anemones retracted their tentacles, and became but a mere rounded lump; the crabs and fishes sought safety beneath the rocks and among the seaweed, and the drill, the animal of which we had hoped to see, had withdrawn into its shell, and closed the aperture tightly with its operculum. This operculum, or door, as the name signifies, is a valuable part of the animal, enabling it to close the aperture against all its enemies. It is placed on the upper surface of the foot, and has a strong muscle attached to it. In large snails this muscle is so powerful that the strongest man could not pull the animal from the

aperture when the operculum is in place. We learned from Professor Parker that the operculum varies greatly in different snails, some being horny, while others are calcareous like the shell. They are nearly all formed on the plan of a spiral, although in some snails, as in the operculum of *Nerita*, it is not at first apparent. If the operculum of the drill be closely examined, it will be seen to have grown from a small nucleus by the addition of new matter, as did the shell of the animal.



General anatomy of periwinkle, Littorina littorea; the animal removed from its shell, and the branchial cavity and back laid open. a, anus; b, branchium, or gill; c, heart; e, stomach; f, liver; g, nervous ganglia surrounding the œsophagus; h, biliary canal; i, intestine; k, buccal mass; l, lingual coil; m, columella muscle; n, aorta; œ, œsophagus; r, rostrum, or proboscis; s, salivary gland; t, foot; x, kidney, or renal organ; y, mucous gland; z, eye. (Woodward.)

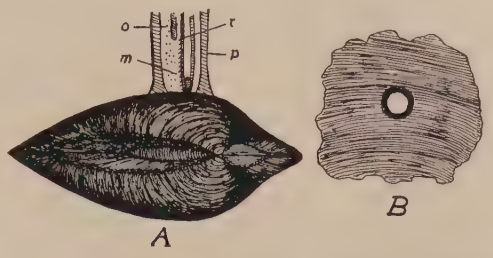
We now placed the drill into the pool again, to see if it would not come out of its shell and crawl about. The first thing to appear was the brownish operculum, which was pushed out of the aperture, and then a flat, muscular disk appeared, which was the foot, or organ of locomotion. The head next appeared, with its pair of tentacles, which bear the black eyes near their bases. Soon the animal was fully extended, and crawled about on its muscular foot.

"If we could take the time to dissect the drill," said the Professor, "we would find that it is a perfect animal, having a brain and nervous system; a digestive system made up of a mouth, teeth, salivary gland, crop, stomach, and intestine; a heart with veins and arteries carrying the blood to all parts of the body; a complicated set of muscles for all its organs, and a gill for the purpose of respiration. In fact, this lowly mollusk is as perfectly fitted for its work in life as are we for ours, and its organs are as perfect, though not, of course, as highly developed. Like nearly all marine snails, it breathes by means of a gill, or branchium, made up of a long central stem or rib, from which a number of leaf-like filaments extend, like the teeth of a comb. The fresh-water breathers also have the same kind of a gill, as we have already learned."

As the Professor was thus talking, he suddenly stooped over and picked up a quahog shell with a peculiar little round hole in it. "Aha!" said he, "here is some of the work of the drill, the animal of which is carnivorous, and lives by boring holes in bivalve shells, through which it may suck the juices of the clam. The drill applies its mouth to the

bivalves, and the radula rasps a hole through the shell by a backward and forward motion, the fine particles of lime filed away being swallowed by the drill. It is said that when the bivalve becomes exhausted, it opens its valves, and that the drill then enters by this opening, as do also other mollusks and crabs which have been waiting for this opportunity."

Feeling rather tired by our walk across the muddy shore, we sat down on the sandy beach above high-water mark, and Professor Parker gave us the following account of the homes of marine mollusks:



A. Diagrammatic figure showing method used by drill in boring a hole in the shell of a clam. m, mouth; o, throat; p, proboscis, or rostrum; r, radula, which works backward and forward over a pulley-like arrangement, and files or rasps the hole.

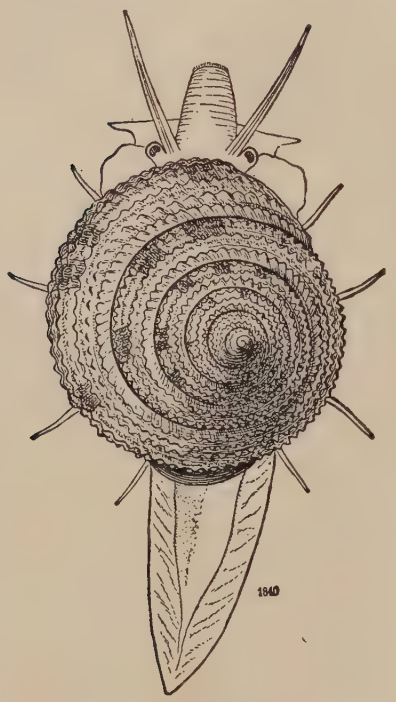
B. Piece of the shell of a quahog, showing the round hole bored by the drill.

"Naturalists have divided the sea into certain definite regions, each characterized by a certain kind of life. One of these divisions varies according to latitude (we speak of the fauna of the arctic regions, of the temperate regions, and of the tropical regions), but the division which I desire to speak about is that of depth. The older naturalists divided the shore regions into the Laminarian zone, or region of brown kelp; and the Coralline zone, or region of stony algæ. Later scientists, however, divide the regions according to other characteristics. Thus, the region bordering the shore which supports marine vegetation, and to which light can penetrate, is called the Littoral region; that of the deep sea, to which no light can penetrate, is called the Abyssal or Benthal region; and the region lying between these two is called Archibenthal. The Littoral region may be said to extend from the shore to a depth of one hundred fathoms, and the conditions are here the most favorable for life, being supplied with warm, fresh currents which afford the animals abundant food.

"The Littoral region may also be divided into several subordinate areas, characterized by the kind of life. The first is the Littoral region proper, which includes that part of the beach lying between high and low water. The next area is called the Laminarian zone, for the reason that the long-leaved kelp, or *Laminaria*, lives chiefly in this region. It extends from low-water mark to about fifteen fathoms in depth. The third area is the Coralline zone, so called because the vegetation consists principally of stony algæ. Small coralline animals, or *Polyzoa*, are abundant, and this region is generally supposed to extend to a depth of one hundred fathoms.

"Beyond the Littoral region the shore gradually slopes into deep water,

and at depths ranging from two thousand five hundred fathoms to five thousand fathoms is the bottom of the ocean. The inhabitants of the deep sea are curious animals, the shells being often of exquisite beauty, both in texture and in color; and are often covered with an epidermis similar to that of fresh-water shells. The bodies of the animals from these regions are flabby and gelatinous in appearance when brought to the surface, but it is believed by scientists that in their native places, under the terrific pressure of a depth of two or three miles below the surface, which cannot be less than one thousand pounds to the square inch, their bodies are compressed to the consistency of iron or steel wire. It is also believed by some conchologists that every molecule of animal matter in the body of the mollusk is in actual contact with a molecule of sea-water. How this can be and the animal still perform the functions of life is not known, but this seems to be the only theory that will account for their ability to withstand such enormous pressure.



Calliostoma bairdii, a deep-water mollusk, dredged in the Atlantic Ocean at a depth of from 56 to 640 fathoms. Dorsal view of living animal and shell. (Verrill.)

"When the operculum is present in deep-sea shells it is horny, and very small when compared to the size of the aperture. That light is present in these great depths we are assured from the presence of well-formed eyes in these animals, many of these organs being out of all proportion to the size of the animal.

"It is also interesting to note the temperatures under which many deep-sea animals live. At a depth of about eight hundred fathoms it is forty degrees Fahrenheit, and from this depth, the temperature falls one-tenth of a degree for every hundred fathoms until the freezing-point is reached. It is not to be supposed, however, that the water in these extreme depths ever actually congeals.

"A large number of deep-sea mollusks have been discovered by the United States Fish Commission's steamers Albatross and Blake, and the British steamer Challenger, and the material collected has been described and figured by such well-known biologists as Dr. W. H. Dall, Professor A. E. Verrill, Rev. Boog Watson, and others. Many interesting accounts

may be found in such books as 'Three Cruises of the Blake,' by Alexander Agassiz, and 'The Depths of the Sea,' by Sir Wyville Thompson. These books may be consulted in almost any library.

"One can hardly realize the difficulty attending the gathering of these animals from such depths. Let us imagine that a dredge is dropped from the top of the Masonic Temple in Chicago, a height of about two hundred and seventy feet, and drawn along the street to catch such insects, mollusks, and other invertebrate life as might be there. It is manifest that only a small percentage of the fauna would be represented by such a method. The depth mentioned is only forty-five fathoms, and if there is difficulty in securing a representative collection for this moderate distance, what must be the almost insurmountable difficulties when that distance is magnified fifty times! Yet with all these difficulties the animals of the abysses of the sea are being collected and classified.

"These animals are being obtained by means of a large dredge, of which you will find a description in the books mentioned above. This work is, of course, beyond the reach of any save a government or a very wealthy person. A little dredging may be done by even a novice, along the shore in waters ranging from two or three to ten fathoms. The dredge should be about two feet wide at the mouth, and of the shape indicated by this drawing which I have roughly made. The netting should be stout, and protected by canvas flaps on each side to prevent it from being torn. A stout manila rope about ten feet long and three-fourths of an inch in diameter should be permanently attached to the ring of one arm of the dredge. The ring of the other arm should be fastened to the ring of this arm by ordinary twine. This may seem somewhat ridiculous at first, but it is really quite important, for should the dredge become caught by a large boulder or other obstruction, a strong pull will break the twine, and the two arms will swing apart, allowing the dredge to be brought to the surface. If both arms were securely fastened by the heavy rope, the dredge could not be freed from the obstruction, and would be lost. The end of the ten-foot rope is made into a stout loop, to which the long dredge rope is knotted.

A marine dredge ready for use. Note the manner of fastening the two arms together at A, so that they will fall apart when an extra strain is brought upon them.

"If a rowboat is used, it should be large and heavy and rowed by two men, each pulling a single oar. The person controlling the dredge should sit in the stern, and between him and the rowers there should

be room enough for a good-sized tub in which to dump the result of the dredging.

"Let us now suppose that we are in a boat ready to dredge. We first put the dredge over the stern, mouth downward, and let it gradually sink, playing out the rope very carefully to avoid knots and twists. I neglected to say that before the dredge is placed in the water, a lead weight of about ten pounds should be fastened to the rope ten or fifteen feet from the mouth of the dredge. This is to keep the mouth in contact with the bottom of the sea, when it is being pulled along. When the dredge is felt to touch the bottom, the dredger should play out enough rope to equal twice the depth. The dredge line is now fastened to a cleat in the stern, and the line allowed to pass over the notch cut in the stern for the sculling oar. This is necessary in order that the rowers may keep in straight line.

"After the dredge touches the bottom, the rowers may pull the boat for quite a distance before the dredge is ready to be pulled up. By the

Sketch showing method of dredging from a rowboat. D, the dredge; w, the weight placed ten feet from the mouth of the dredge. (Dall.)

peculiar vibrations of the line, one soon learns to judge correctly when the dredge is on the bottom, when it is catching well, when it is caught by some obstruction, or when it is not catching at all. When the dredge is thought to be full it may be pulled up and its contents dumped into the tub. It is sometimes well to examine the material near the mouth of the dredge for fear there may be some very delicate specimens which may be broken. The material in the tub may afterwards be picked over and the specimens properly cleaned. Notes should always be made regarding each haul of the dredge, giving all possible

information relative to the characteristics of the bottom (whether sandy, muddy, gravelly, or weedy), the date, the depth, and any other items of interest. It is desirable that each haul of the dredge be kept separate, and for this purpose several tubs, or other receptacles, will be found necessary. A fine wire sieve will be found useful in washing the material.

"Every variety of shore supports a certain type of mollusk, which also varies in different latitudes. Thus a rocky shore is especially adapted for *Chitons*, limpets, and periwinkles, and a sandy beach is the favorite home of the *Naticas*, or moon shells, the *Nassas*, or basket shells, and the large *Fulgur*, or winkle shell, and of course the bivalves specially abound in muddy and sandy beaches. In tropical regions the coral reefs are fairly alive with mollusks. The student must learn by experience just what species live in each kind of a locality."

Fulgur canaliculatus, the common winkle shell of the New England states. (Dall.)

Having rested ourselves, we now removed our shoes and stockings, rolled up our trousers, and walked toward the water, determined to thoroughly explore the shore for mollusks. When about half-way across the beach, Harry found a horse-foot crab, the outside and inside of whose shell was covered with rounded, flattened shells. Professor Parker said that these were the slipper shells, or *Crepidulas*, and we proceeded to strip the crustacean of every one of its ornaments, and no less than a hundred shells of various sizes were taken from this crab.

We soon reached the rocky shore which the tide had left uncovered, and each of us began to eagerly search for shells. The rocks were slippery, and covered with great masses of seaweed, while the little pools left in the hollows were filled with the most gorgeously colored weeds — green, red, and pink — which waved gracefully about in the eddying waters. The rocks were tenanted by millions of the periwinkles, whose shells of black, yellow, and red seemed to be everywhere. The purple shells (*Purpura*) were also very abundant, and George was fortunate enough to find several limpets neatly tucked away on the under side of an overhanging rock. Some of the seaweed was filled with the minute shells of *Cerithium*, and the little pools contained several specimens of the naked sea slugs (*Doris*). The sea slugs were very curious, with their peculiar shapes, brilliant colors, and odd, plume-like

breathing organs extending from the back of their bodies. Howard found several graceful ladder shells (*Scala*) in one pool, and he was the only one of us who was so fortunate. In the same pool he saw a peculiar shell to which he called our attention. It was a large spiral shell which was inhabited by a hermit crab, and its surface was covered with little coral animals called *Hydractinia*.

Hermit crab in shell of Polinices heros, one of the moon shells. (Goode.)

Professor Parker, who had gone some distance ahead, now called to us, and we hastened to him. As we approached we saw him stooping over and looking at the under side of an overhanging rock; we leaned over a small pool of water, and the Professor pointed out a little bunch of graceful, vase-like objects, about a quarter of an inch high. These were the egg capsules of the purple shell, *Purpura lapillus*.

Not far from the *Purpura* eggs Howard discovered several flattened objects resembling the little pill bugs so common under old boards in damp places. We asked Professor Parker what these were. "These," replied he, "are *Chitons*, or coat-of-mail shells, the back being protected by eight pieces instead of one, as in the other snails. If you wish to preserve any of these mollusks you must tie them to a flat piece of wood to keep them from rolling or coiling up."

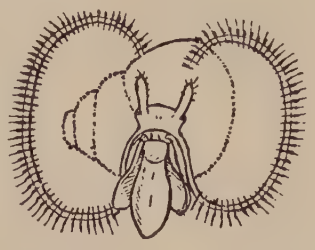
This spot proved a perfect mine of shells, and we collected over thirty different species. The seaweed was tenanted by small dove shells (*Columbella*) and the little *Cerithites*, while the sand in the little pools of water contained numerous minute shells, besides some periwinkles, drills, basket shells, and a few delicate bubble shells, or *Bullas*.

As the tide was now coming in very rapidly, we started toward the shore. On the way George came across several living moon shells buried in the sand, and near them he noticed a peculiar collarlike object made of sand, to the under side of which a multitude of small, yellowish objects were attached. Professor Parker said that these were the eggs of the *Natica*, and that the collar was called a nidus. Not far away we found several long strings of the flat capsules of *Fulgur*, and near them a large living specimen which had been thrown up by the tide. Near a dead fish we saw a multitude of the black basket shell, *Nassa obsoleta*, eating its flesh. There was a perfect procession of *Nassas* from all directions, headed toward the fish. The Professor said that the *Nassas*, being

natural scavengers, have a powerful sense of smell, and had probably scented the fish a long way off. These mollusks seemed to be able to live as well out of the water as in it.

Reaching the shore, we ate our dinner, and then returned to the station by a route which took us across a salt marsh, in which we found a large number of the amphibious snail *Melampus*, which always lives in the vicinity of the sea. A large mussel, *Modiola plicatula*, was found here in great abundance.

About the middle of the afternoon, we took the train for Providence, and settling back in the comfortable seats, plied Professor Parker with questions. George wanted to know how the shells grew, and if the young animal was like the old one. "No," replied the Professor, "the young are quite different. After leaving the egg, the young mollusk, which is very small, is called a veliger larva, and swims about by means of two lobes, or vela, which are placed on each side of the animal and are covered with hairs, or cilia, by the rapid motion of which the larva swims about. All mollusks are free and active when young, and spend a greater or lesser time in swimming about. As the organs become more developed, the vela gradually disappear, the head, foot, tentacles, heart, and other organs are formed, and the young mollusk sinks to the bottom of the sea, and takes up its adult condition. If an attached species, it fastens itself to some object; if a free-moving snail, it selects some rocky or sandy spot for its home. You will observe from this rough sketch which I have made, that the young mollusk is as different from the adult animal as the caterpillar is from the butterfly."



Veliger larva, or young of Rissoa costata, a minute gastropod. The vela or ciliated lobes are seen on each side of the animal, and the eyes, foot, and tentacles are seen in the center. (Tryon.)

We arrived home at supper-time, tired in body, and as Harry expressed it, "as hungry as wolves."

SOME SNAILS OF THE OCEAN

Several days after the collecting trip to Apponaug, we again visited Boston; this time to remain a week and study, with the aid of Professor Parker, the many varieties of marine snails in the different museums of that city. During that time we learned the following valuable and interesting facts concerning these animals:

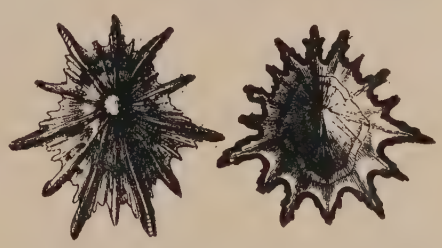
Tooth shell. Dentalium elephantinum. (Tryon.)

The marine snails outnumber all of the other mollusks, and their shells are far more beautiful, those in the tropics having the most gaudy colors imaginable. The animals are all formed on the same plan, although each family has some peculiarity not shared by its relatives. They are found in all parts of the world, those of the tropics, however, being the most brilliantly colored. While the majority of species live either between tides or near low water, there are not a few which live in the abysses of the ocean, and have been obtained by dredging at a depth of three thousand fathoms, which is more than three miles. The average depth at which mollusks are found in any number is about one thousand fathoms. The variability of marine snails is so great that only a few typical forms can be mentioned.

One of the most curious of marine mollusks is the *Dentalium*, or tooth shell, which is a member of the class *Scaphopoda*. The shells vary from the fraction of an inch to over four inches in length, and in color from white to dark green. The *Dentalium* burrows in the sand and lies there in a slanting position, the little end being upward and above the sand, for the purpose of respiration. The large end is armed with a number of long tentacles which terminate in small, rounded clubs. These feel about in the sand and catch foramanifera, or minute bivalves, which they convey to the mouth of the animal. The *Dentalium* has no eyes, but is provided with ears in the form of several vibrating organs. The *Scaphopods* serve as food for a variety of other mollusks. In former times, the tooth shells were used for personal adornment, as well as for money, by the Indians of the Pacific coast. At one time a string of twenty-five

large shells were equivalent in value to two hundred and fifty dollars, and would purchase a canoe or a squaw. The Indians have a unique method of catching these shells. While the squaw paddles the boat slowly along, the Indian stands in the prow and plunges a comb-like spear into the sand. If successful, his spear comes from the water with several of these animals impaled upon it.

The most peculiar of all the mollusks, so peculiar indeed, that they constitute a separate class, called *Amphineura*, are the *Chitons*, or coat-of-mail shells. The shell is made up of eight separate pieces or plates, each interlocking with the other, the whole supported by and buried in a coriaceous mantle, which forms a margin all the way around. This must not be confounded with the true mantle of the animal, for it is only a part of the shell. It is beset with bristles, spines, or hairs, which add much to the peculiar appearance of the mollusk. In some species, well-formed eyes are developed along the sides of this mantle. The *Chitons*, which are said to be nocturnal in habit, feeding only at night, live for the most part on rocks which are exposed at low water. Their movements are slow, and they appear to be very sluggish in all their actions. When detached and taken from their rocky homes, they have the provoking habit of rolling up like a pill bug, and are sometimes very difficult to straighten out again. When placed on their backs, they sometimes right themselves by violently contorting their valves. In various parts of the world they are eaten by natives, and by the poorer classes. The Iceland fishermen believe that if these "sea-bugs," as they call them, are swallowed raw they will prevent seasickness and also quench thirst. It is probable that the cure would prove worse than the disease for most people who cross the ocean. There are about two hundred and fifty species of *Chitons*, and they may be found in all parts of the world.



Patella longicosta, a limpet which lives at the Cape of Good Hope. Left figure, outside; right figure, inside of shell. (Tryon.)

The limpet, or *Patella*, is a familiar mollusk to many visitors at the seashore. This shell is a depressed, conical, oval disk, looking not unlike a miniature shield. It lives on rocks, to which it clings with great tenacity. Some experiments which were made on the English limpet some years ago, showed that it could sustain a weight of thirty pounds attached to its shell without being pulled from the rock. The animal seems to have a pretty clear idea of local geography, for it invariably returns to the same place after its excursions for food, and the

rock in some localities has been hollowed out to a considerable depth by the continuous dwelling thereon of the limpet. If the surface of the rock is uneven, the shell grows in such a manner as to fit these inequalities. The large foot is very strong, and it is almost impossible to dislodge it from the rock when the animal becomes alarmed and is aware that danger is near. While grazing along the sides of a rock covered with fine seaweed, it will leave a track like a worm, and will clear off quite an area in a short space of time. This track is made by the radula, which is very long and is thrust out and loaded with food, which it carries to the mouth. When at rest, it is coiled like a watchspring.

In the limpet we find a departure from the general form in both animal and shell, both being bilaterally symmetrical; that is, having the two sides alike. In the majority of snails, the body is twisted in the form of a spiral, making one side different from the other, and causing the organs of one side to become atrophied, or made very much smaller. In the limpets the organs are paired, as they are supposed to have been in the ancestors of the living mollusks. On the British coast, the limpet is used as an article of food, and primitive man not only ate the mollusks but formed a necklace by stringing the shells together. There are several hundred species of limpet-like shells, and they are found in all parts of the world, though generally on rocky shores.

A family of shells closely related to the limpets is the *Fissurellidæ*, or keyhole limpet, distinguished from the last family by having a slit, or foramen, in the apex of the shell, through which the waste products of digestion are discharged. This slit resembles a keyhole, and for this reason they are called keyhole limpets. The shells of *Fissurella* are generally rougher than those of the *Patella*, and they live, as a rule, in warm seas. In habits, the keyhole limpet resembles its relative the limpet, living in one rocky place and making excursions for food. In the young shell the spire is without a perforation, this appearing as the shell increases in age. There are over a hundred species of this family, several handsome species of which inhabit Florida and the West Indies.

The *Haliotis*, or abalone shells, abound in many parts of the world, and are widely known for their beauty. The largest and finest shells live on the coast of California, where they attain a length of ten inches. The shells are flat, though made in the form of a spiral, and are perforated near the edge of the last whorl, which is many times the size of all the rest combined. Through these holes the water from the gills, together with the waste products of the animal, pour out. As the shell increases in size, the old holes are filled up and new ones are formed.

The inside of the shell is resplendent with iridescent colors, particularly about the region of the huge muscle scar, and when the outside is polished they become objects fit for the palace of a king. A large part of the mother-of-pearl of commerce is furnished by these shells, and a vast number are annually exported for the purpose of making pearl buttons. In England they are called "Ormers," but the correct name, if we translate the generic title, is "sea-ear," or ear shells. To the Chinese, the abalone is an object of great commercial importance, and they gather them in large numbers, dry the animals and use them as food, principally in the form of soup, which is said to be very delicious. The abalone clings to the rocks with terrible power, and many a lonely fisherman has been drowned while gathering these mollusks, by getting his fingers caught between the shell and the rock. A method employed by the Chinese is to take a crowbar, and stealing up to the animal, give it a sudden push before it is aware of danger. This method is generally successful.

The animal of the *Haliotis* is no less interesting than the shell, having a broad foot, tapering, slender tentacles, stalked eyes, and a mantle which is fringed with slender, tentacle-like organs. Five different species of ear shells live on the coast of California, all of which are celebrated for their beauty.

There are three families of shells which are much sought after by conchologists: these are the top shells *(Trochidæ)*, the turban shells *(Turbinidæ)*, and the pheasant shells *(Phasianellidæ)*. Altogether, they embrace nearly five hundred species, which live from the shore between tides to the lowest depths of the ocean. The shells of the top shells vary to a wonderful degree: some are large, others small; some are perfectly plain and smooth, while others are ornamented by impressed ribs, lines, and granules; some are very thin and delicate, while others are large and massive. Many of the species are richly colored with brown, purple, black, green, and yellowish, and all are more or less pearly. They are all vegetable eaters. One of the best known of the top shells is *Trochus niloticus*, a large, massive shell, striped with brown, which is seen on the mantel of many households. One of the prettiest top shells is the ringed top shell, *Calliostoma annulatum*, found abundantly in some parts of California. The surface is marked by several rows of delicate points, and the suture is bordered by a rich line of purple. It lives in the seaweeds off shore, and in pleasant weather

Calliostoma zizyphinum, the common top-shell of the Mediterranean Sea, as it appears when the animal is crawling over the bottom of the ocean. (Tryon.)

it may be seen crawling about in this vegetation. During storms or rough weather this frail mollusk sinks to the bottom of the sea. The top shells inhabit many parts of the world, the coasts of California and Florida producing several very interesting and handsome species.

The turban shells include many large and fine shells, a notable species being *Turbo marmoratus*, the "green turban" of the dealers. This shell is about seven inches in diameter, is of a rich green color outside, and has a pearly inner face. The shell is largely used for mother-of-pearl work and for making pearl buttons. It is said that the early Scandinavian monarchs used this shell as a drinking-cup, and at the present time it is often richly mounted and used for ornamental purposes. In Japan, the animal is used for making chop suey, being cut into little disk-like pieces. Some of the smaller shells of this family are very beautifully colored, as the *Turbo petholatus* and the *Turbo sarmaticus*, or Turk's cap, the latter being much used by dealers in making fancy ornaments.

The pheasant shells are beautifully variegated with red, black, white, and brown, and are very interesting animals to study alive. When crawling, the left side of the foot moves forward while the right remains stationary, and when the right side moves the left remains stationary. This curious mode of progression has been likened to the canter of a horse. The larger species, with beautifully variegated shells, inhabit Australia, while the smaller species live in the Mediterranean Sea, South Africa, the West Indies, and California.

The *Neritas* are very abundant in tropical and semitropical countries, where they live on rocks and stones, near low-water mark. They are said to be nocturnal, and to spend the night feeding on seaweed. The shell of *Nerita* is solid and heavy, and variously ornamented with ribs, pustules, and color patterns. The columella is modified by several teeth, and the operculum is shelly and provided with a little hook by which it articulates with the toothed columella. The "bleeding tooth" shell, *Nerita peloronta*, so named because of the presence of a red spot near one of the columella teeth, is a typical member of this genus. A species living in the Philippine Islands is said to climb trees to a considerable height. What the *Neritas* lack in color the *Neritinas*, or little *Neritas*, fully make up, with their smooth, globular shells, ornamented with bands of various colors. One species, *Neritina virginea*, which is very abundant in Florida and the West Indies, is so variable that scarcely any two shells are alike. Some individuals are spotted with white on a gray ground; others are banded with white, drab, and red, and are rosy with spots of color mixed in, while many are perfectly plain. The

animals are quite amphibious, some of them living on the roots and leaves of the vegetation which overhangs the water. A small British species, *Neritina fluviatilis*, lives in the rivers of England, but the great majority of species live in salt or brackish water.

The family *Cerithiidæ* comprises some very handsome shells which inhabit salt, brackish, or fresh water. They are found throughout the world, but the finest species live in the tropics. The spire is very long, and is composed of many whorls. Some shells are smooth and polished, while others are marked by frills, knobs, spines, and ribs. The name *Cerithium* is from the Greek, ceration, meaning a small horn, and is given because of the horn-like shape of the shell. This family has its giants and also its pigmies. The latter are pretty, reticulated shells, from one-fourth to three-fourths of an inch in length, which live among the eel-grasses and other vegetation along the shore. There are over one hundred species of these small shells, some with dextral and others with sinistral apertures. When handled, some of these mollusks discharge a bright green fluid.

The *Potamides*, comprising the fresh and brackish water *Cerithites*, generally have blackish shells without color markings, and inhabit streams, swamps, and salt marshes. Some of the species are able to suspend themselves from bushes by means of glutinous threads. In many of the islands of the Indian and Pacific oceans the animal is roasted and eaten by the natives, who suck the contents through a hole in the spire.

Whoever visits the seashore is bound to become intimately acquainted with the *Littorinas* or periwinkles, for they cover the rocky shores everywhere, millions of their rounded shells clinging to the rocks when the tide goes out. They live principally in the littoral region, feeding on the algæ which grows near the shore. They are also found both in brackish and in fresh water. The common periwinkle, *Littorina littorea*, is extremely abundant on the shores of southern Europe and in the northern part of the United States. In England it is used as an article of food, and it is said that nearly two thousand tons are gathered annually, and a thousand persons are employed in their capture. In London and in other large cities they are sold on the streets in the same manner that we sell peanuts, and the animal is picked out with a pin. It is used for bait in some of the fisheries, and the oystermen annually plant many bushels on their oyster beds to keep the seaweeds from accumulating. From these facts it will be seen that this periwinkle is of considerable economic importance. This species is also remarkable for the length of its radula, which is coiled in the

head like a watchspring. The shell is about an inch long, while the radula, when stretched out, measures two and a half inches. This great length is necessary because it rapidly wears out on the front end while scraping the algæ from the rocks, and the worn part must be quickly replaced. The shells of the northern species are not very handsome, being black, brownish, or yellow, but some of those living in the tropics, as the *Littorina angulifera*, are very attractive, their shells being taste-

A good locality for Littorinas, Newport, Rhode Island.

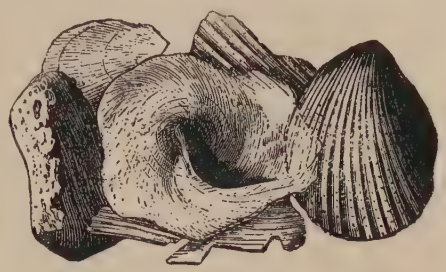
fully mottled. All of the species are amphibious, living for a long time out of the water. It is recorded that several specimens of a West Indian species lived in a gentleman's cabinet for over a year.

A genus of small shells related to *Littorina* is *Lacuna*, the animal of which presents a good example of protective coloration. It feeds upon seaweed, and when the weed is brown the animal becomes brownish; when the weed is red the animal is of a rosy tint.

A singular genus of mollusks is the *Vermetus*, or worm shell, which is frequently mistaken for a true worm. The shell of a Florida species is ten inches long. It starts out like other shells, but after making six or eight whorls it suddenly forms a long, irregular tube. In an allied genus, *Turritella*, or the screw shells, the whorls are from twenty

to twenty-five in number, are gracefully rounded, and often marked by many raised spiral lines. The aperture is about one-eighth the length of the spire, which is long and tapering.

Of all the *Gastropods*, none excel the curious *Xenophora* in point of oddity. Its shell is in general form like that of the top shell, but as it grows, it attaches to itself small stones and pieces of shell so that when the animal is fully grown it looks like a heap of dead shells and pebbles. This habit is, in all probability, for the purpose of concealing itself from enemies. They are called "carriers," and the individuals with shells attached to their houses are called conchologists, while those with stones so attached are called mineralogists. The fragments of shells are attached with concave sides upward so as not to impede the progress of the animal during locomotion. The carriers are not able to glide as are other mollusks, as their foot is very small. They progress by fixing the front part of the foot to an object, and then drawing the hind part forward. In this way they jump and scramble along in a ludicrous manner.



A carrier shell. Xenophora conchyliophorus. (Tryon.)

Related to the "carriers" are the slipper shells *(Crepidula)*, the horse-hoof shell *(Hipponyx)*, and the bonnet limpet *(Capulus)*. The slipper shells are found in many parts of the world, and are particularly abundant on the Atlantic and Pacific coasts of the United States. The shell is flat and somewhat limpet-like, and across one end, near the apex, is a little shelf, which gives the likeness to a Chinese slipper. They adhere to stones, shells, crabs, and any submerged object, and modify the form of their shell to fit the inequalities of their resting-place; thus, a *Crepidula* on a pecten shell will be ribbed, while the same species on a stone will be perfectly smooth. Frequently they may be seen piled one upon another in tiers of six or more. Though the animal generally feeds upon the seaweeds, it has been known to feed upon other mollusks. The bonnet limpets also belong to this family, as do the cup and saucer limpets *(Calyptræa)*. Some of the bonnet limpets are believed never to leave the spot to which they have become attached.

We now come to a family noted for its blood-thirsty nature. This is represented by the genus *Natica*, or the moon shell. The animal is quick in movement as it plows its way through the sand with its enormous foot, in search of bivalves. When one is found, the radula

is set in motion and in a short time a hole is bored through the clam and the moon shell quietly enjoys a hearty meal, sucking the juices of the animal through the hole. The shells are globular, from which they receive their common name, and those of the tropics are beautifully marked with purple, brown, yellow, and other colors, while not a few are perfectly white. The *Sigaretus*, a genus closely allied to *Natica*, has a flat, whitish or brownish, ear-shaped shell; its habits are the opposite of those of the moon shell. It is slow and very timid, and constantly explores the neighborhood when in motion. Both the *Natica* and the *Sigaretus* burrow in the sand, and their presence may often be known by the rounded heap formed by the back of the shell.

The family *Strombidæ* contains many large and interesting shells. The animal is very powerful, and is able to leap to a considerable distance. Mr. Arthur Adams, a celebrated English conchologist, thus describes its method of leaping: "Planting firmly its powerful narrow operculum against any resisting surface, it insinuates it under the edge of its shell, and by a vigorous effort, throwing itself forwards, carrying its great heavy shell with it, the animal rolls along in a series of jumps in a most singular and grotesque manner." The eyes of the animal are largely developed, and are placed on a stem or peduncle. The shells of *Strombus* vary greatly in both form and color. In some, the outer lip is simply turned over, while in others, it is modified by little spines or long projections. The apertures are frequently colored pink, purple, or yellowish. The large *Strombus gigas* is used in carving cameos, its shell being made up of several layers of different colors. It is also ground to powder for the manufacture of porcelain, and in the West Indies the animal is used as an article of food. The *Pterocera*, or spider shell, is related to the *Strombus*, as is also the pelican's foot shell, *Aporrhais*. The spider shell receives its common name on account of the long, curved spines which extend from the lip in the adult shell.

Strombus gigas with animal in its natural position. (Tryon.)

The augur, or steeple shells, belonging to the family *Terebridæ*, have long been objects of interest not only to the naturalist, but to the layman, who places them in his house as ornaments. There are about two hundred species which, although confined mostly to the tropics, are found in many parts of the world. The shells are very long, and are composed of many tightly wound whorls, which are smooth in some

species and longitudinally ribbed in others. They also vary in color, being yellowish, grayish, or brownish, and many species are spotted with white or red.

There is a group of handsome mollusks living in the tropics whose shells have been named *Mitra* by the naturalist Lamarck, from their fancied resemblance to the pope's miter. The shells are fusiform, very thick and heavy, and beautifully ornamented with various colors. The surface of the shells of some species is smooth, others are granulose, and not a few are spirally lined and longitudinally ribbed, while the columella is marked by several heavy plaits or folds. There are about two hundred species of this genus, living in all parts of the world, but they are more numerous in tropical regions. The Philippine Islands seem to be the metropolis of this mollusk as of others, and their shores fairly teem with the graceful creatures. Some of them live among the coral reefs, concealing themselves in holes and among the seaweed, or under stones. Others live on the sandy or muddy beaches, in which they bury themselves when the tide recedes. Some of the species are entirely covered with mud, and when in this condition they are hard to distinguish. Most of the species love company, and generally a dozen or more individuals may be seen crawling over the sand, like the basket shells. The smaller species are quite active; but the larger species, probably owing to the heavy shell, are quite slow, the foot being rather small as compared with the shell. Many of the species are nocturnal, and remain hidden under coral and stones, or buried in the sand during the day. When disturbed, they are said to emit a purple fluid of disagreeable odor.

The early naturalists were fond of applying significant names to the various shells which they described, and the *Mitras* have received their share. Thus we have the episcopal miter, *Mitra episcopalis*, having a white shell with brilliant red spots and flames; the papal miter, *Mitra papalis*, with a brown spotted, whitish shell; the pontifical miter, *Mitra pontificalis*, with a red spotted shell and a coronated spire; and lastly the cardinal's miter, *Mitra cardinalis*. These four species might be called the ecclesiastical quartette. The shells of *Mitra* vary from one-half to five inches in length. In a nearly related genus, *Turricula*, the shell is very broad, heavily ribbed longitudinally, and the colors are red, ashy, or brownish, with an occasional black spiral band. This genus of one hundred and sixty species is found only in the tropics and subtropics, and is most abundant in Central Polynesia.

The harp shells, although few in species, are among the most showy of the marine snails. Their shells are large, and marked by many

elevated ribs extending longitudinally, giving the effect of the strings on a harp, whence the name of the genus (*Harpa*). The colors are different shades of brown, which form neat festoons of dark brown lines between the ribs. The inner lip of the shell is marked by a dark brown spot, and another spot is frequently developed near the upper part of the whorl. In one species, *Harpa rosea*, the shell is marked by several rosy spots and tints, which make a very beautiful shell. The animal of this genus is no less interesting than the shell, being variegated with many beautiful colors. The foot is long, crescent-shaped in front, and becomes narrowed to a point behind. The animal is said to voluntarily break off a piece of its foot when irritated, as it is not able to retreat within its shell. It is destitute of an operculum. It is very active, and crawls about with an easy, graceful motion. *Harpa* lives only in the tropics, and is found in the Indian and Pacific oceans, and on the west coast of America.

Harpa ventricosa, one of the most beautiful of the harp shells. (Tryon.)

The bubble shells include among their number many curious and interesting animals. The typical genus, *Bulla*, numbers some fifty species of smooth, globular shells, frequently mottled like a bird's egg. The aperture is as long as the shell, and the outer lip is thin and sharp. The animal is large and fleshy, and partly envelops the shell. The bubble shells love sandy, mud flats, in which they bury themselves, or find concealment under masses of seaweed. Like many land shells, they exude vast quantities of mucus to moisten their skin when the tide is out. These animals are carnivorous, living on bivalves and snails, which are swallowed whole and reduced to fragments by their huge, calcareous gizzards.

A sea hare. Aplysia depilans. (Tryon.)

The species of bubble shells are quite numerous in the waters bordering the Atlantic and the Pacific coasts of the United States, no less than sixty species living on the eastern coast and about thirty species on the western coast. Among the latter the *Bulla nebulosa*, which attains a length of two inches, is the largest and finest. The eastern species are much smaller, none measuring more than an inch in length and many of them being exceedingly minute. Many of the bubble shells are difficult to collect alive with

perfect shells, because they are so fragile that they will break at the slightest touch. Much care is necessary to obtain unbroken specimens.

The order to which the bubble shells belong, the *Tectibranchiata,* comprises several hundred mollusks whose shells are similar in form to the bubble shells. Some are large and others are very small, some thick and solid, while others are thin as paper. The color is generally whitish, but in some species it is greenish, brownish, reddish, or banded with red and white like the ship's-flag bubble shell, *Aplustrum.* In the boatman bubble shell (*Scaphander*) the calcareous gizzard is a third as large as the entire shell, the tooth shell, *Dentalium entalis,* being its principal food. Not all of the mollusks of this order have shells. The sea hares (*Aplysia*) have large, flabby bodies in which is lodged a small, oblong, transparent shell. This animal lives among the seaweed, feeding upon the vegetation as well as upon mollusks and other animals. It discharges a violet liquid when handled, which caused the ancients to believe that it was poisonous. The old Greek philosophers wrote a great deal on this subject, believing that to even touch the animal with a stick would cause death. Though repulsive looking creatures, they are perfectly harmless, and are even eaten by the natives of the Friendly and the Society Islands.

THE COWRIES, SHELL MONEY, AND THE ROCK SHELLS

THE COWRIES

For some time, our quartette had been anxious to learn more in regard to the cowries, shell money, and the rock shells; so one rainy day, we induced the Professor to give us a talk on these subjects. We comfortably seated ourselves in his sitting-room at the hotel, and spent a profitable afternoon listening to his instructive words. We took notes from time to time, and were able to remember many of the interesting facts which he gave us. Though the rain prevented the fulfillment of our plans for adding to our collections of specimens, we all decided that the rainy day proved a "red letter day" in our search for information.

The Professor placed himself in the center of the group and began by saying, that among marine mollusks none stand so favorably in the eyes of collectors, or are as beautiful as the Cypræas, or cowry shells. With their glossy coats and varied colors they are indeed gems of the ocean, and it is but little wonder that the conchologist has placed them first among the many families of marine shells.

He then continued: "The name *Cypræa* is from Cypris, one of the names of the goddess Venus. About two hundred recent species have been described, and they are found in nearly all parts of the world, though more numerous in the tropics and subtropics, where they live on coral reefs and under rocks. As in many other genera of shells, the cowries that live in the tropics are more brilliantly colored than those from more temperate climes; a condition which is due to the large amount of sunshine and the high temperature, both of these factors being essential to the secretion of coloring matter in the pigment cells of the animal.

"The animal which inhabits a cowry shell is a curiosity. The foot is large and spreads out in a wide mass, enabling the animal to glide along quite rapidly. The mantle lobes are folded over the back of the shell, and are beset with many little tuft-like organs, which stick out like the young shoots of a plant. The mouth is placed at the end

FROM COL. CHI. ACAD. SCIENCES.

COPYRIGHT 1900, BY A. W. MUMFORD, CHICAGO.

ROCK SHELLS.

Murex radix (Panama).
Murex adustus (East Indies).
Murex trunculus (Mediterranean Sea).

Murex pomum (Florida).
Murex tribulus (China).

Murex ramosus (Indian Ocean).
Murex axicornis (Amboina).
Murex bicolor (Panama).

of a rather long snout, or rostrum, and the eyes are upon the outside of two long, tapering tentacles, about one-third the distance from the body. When the shell is young, it is covered with a thin epidermis, and has a thin, sharp, outer lip not unlike some snails; when it is full grown, the outer lip rolls inward, becomes toothed or ridged, as does also the inner lip, and the aperture becomes but a long and narrow slit reaching from the apex to the base of the shell. The mantle lobes, which are inconspicuous in the young shell, become large, and are reflected over the back, and deposit coat after coat of shelly enamel until the first pattern of the shell, as well as the epidermis, is covered with a secondary, shining coat. On most *Cypræas* there is a line of paler color, showing where the two lobes of the mantle meet on the back. Like many other mollusks, the *Cypræa* is able to dissolve the internal whorls, and thus enlarge the capacity of its shell. This is also true of *Conus*. *Murex* and some other marine shells dissolve the spines which may be in the way when increasing the size of the whorls. The older naturalists, Lamarck and Bruguiere, believed that the *Cypræa* was able to dissolve its outer lip after it had been rolled over and toothed, but this theory has been proven incorrect. They founded their belief on the fact that some individuals of the same species were larger than others. This, however, is due simply to individual variation, just as in man, some are large and others are small.

Animal of Cypræa tigris crawling. e, eye; f, foot; m, mantle, with tuft-like projections; r, rostrum; s, shell; t, tentacles. (Tryon.)

"The beautiful colors, which are so much admired, are deposited by the reflected mantle, and their variety is almost endless. Some are perfectly plain — white, brownish, yellow, or orange — others are spotted with red, white, brown, drab, or black, and still others are variously banded. The eyed cowry, *Cypræa argus*, has large, dark brown spots on a lighter background.

"In form and sculpture the cowries present a rather wide range of variation. The typical form is more or less cylindrical or pyriform, while others are flat, oval, or egg-shaped. The surface varies from smooth to spirally lined and pustulose. In size, they vary from the little *Trivia exigua*, scarcely one-fourth of an inch long, to the huge *Cypræa testudinaria*, nearly five inches in length. Many of the larger species, like the tiger cowry, *Cypræa tigris*, and the black cowry,

Cypræa mauritiana, have been household ornaments for centuries, and have also served as playthings for young children, who have held them to their ears to hear 'the sound of the roaring sea.'

"In habits, the cowries are shy and slow in movement, gliding over the coral reefs and marine vegetation with a sluggish, steady motion. They present a beautiful sight when viewed through the water, their brilliant colors vieing with those of the corals, sea anemones, and seaweeds. They are said to feed principally upon the coral animals.

"From very ancient times the cowries have been used for adornment or for barter, the *Cypræa annulus*, or ringed cowry, having been found by Dr. Layard in the ruins of Nimrud; it is stated that the same species is now used by the islanders of the Indian and Pacific oceans to weight their fish-nets and to adorn their persons. In western Africa, the money cowry, *Cypræa moneta*, has been and is now used as a medium of exchange in place of gold. Many tons were yearly shipped to England from the Indian and Pacific oceans, to be again carried to Africa to barter with the natives for ivory and other articles.

"The number of cowries which have been given for various articles, with their value in American currency, is interesting. Thus it is recorded by the conchologist Reeve that a gentleman residing at Cuttack, in India, paid for the building of his bungalow entirely in cowries, giving over sixteen million specimens. The value of these cowries was four thousand rupees sicca in Indian money, or about two thousand dollars in American money. In another place it is recorded that a young wife cost from sixty thousand to a million cowries, or from nineteen to thirty-seven dollars, while an ordinary wife cost but twenty thousand shells, or about six dollars.

"The value of cowries varies in different countries. In India, one rupee is worth five thousand or six thousand cowries, while in parts of Africa, two hundred cowries are worth sixteen cents. In Sudan two thousand cowries, which weigh seven pounds, are worth one dollar. On the west coast of Africa, where trading in cowries is largely carried on, the following gradation of value is recorded by Dr. Stearns:

40 cowries = 1 string,	10 heads = 1 bag,
2½ strings = 1 penny,	2,000 cowries = 1 head,
100 cowries = 1 penny,	3 heads = 1 dollar,
50 strings = 1 head of cowries,	20,000 cowries = 1 bag.

In other places the value is about 1*s.* 3*d.* for 1,000 shells.

The money cowry is also used for ornaments upon the trappings of horses and elephants, as well as on the persons of men and women. The rich, yellow variety is much sought after by the chiefs of several

island tribes, who permit no one but themselves and their sub-chiefs to wear them. We may truly say that of all the mollusks, large or small, handsome or ugly, the modest little money cowry surpasses any in point of economic importance. In the Friendly Islands, the orange cowry, *Cyprœa aurantia*, is used as a badge of chieftainship, and for a long time specimens were almost priceless because none but the chief was allowed to wear this ornament. Specimens of this species are frequently seen in collections, with a hole in the back by means of which it was suspended about the neck of the native chief.

"Those who have described the cowries have given them many fanciful names, some of which, however, are quite appropriate. Thus we have the *caputserpentis*, or serpent's head; the *arabica*, or arabic shell, so named from the peculiar hieroglyphic-like characters on its back; the *lynx*, *pantherina*, and *tigris*, each shell resembling the coat of the lynx, panther, and tiger; *mus*, the rat shell; *rhinoceros*, the rhinoceros shell; *turdus*, the thrush, and *cervus*, the deer. Many of the other names are equally well chosen, as *mappa*, the map cowry, and *pustulata*, the pustulose cowry.

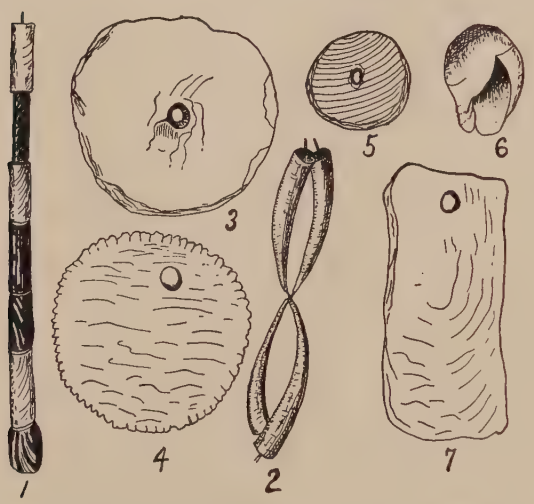
The lynx cowry, Cypræa lynx, which lives in the Indian Ocean. (Tryon.)

"It is interesting to note the prices that have been paid for rare specimens of this family. At an auction held in London many years ago, a specimen of *Cyprœa guttata* brought two hundred dollars, and *Cyprœa princeps*, another very rare shell, brought the same price. *Cyprœa umbilicata* once sold for one hundred and fifty dollars, but may now be had for five dollars. *Aurantia*, the orange cowry, was once almost priceless, but is now sold for from fifteen to forty dollars. Some of the others which are less rare are *Cyprœa scottii*, worth from five to eight dollars, and *Cyprœa decipiens*, from fifteen to twenty dollars. These extravagant prices need not be paid by any one desiring a collection of these pretty shells, for the price of a single rarity will suffice to purchase the majority of the common species. Several private collections in the United States contain from one hundred and fifty to one hundred and seventy species, including a number of the rarities mentioned.

OTHER SHELL MONEY

"In connection with the *Cyprœas* it is of interest to notice other species of mollusks which have been used as shell money. The North American Indians used fragments of shells as money, which they called

wampum. In New England, wampum was in the form of beads, the manufacture of which required considerable skill. These beads were cylindrical in form, about one-fourth of an inch long and half as wide. These were of two colors, and were drilled and strung on long cords. The quahog, *Venus mercenaria*, was much used in the manufacture of shell money because of its two distinct colors, pure white and deep purple. The white beads were called wampum, or wompom, and the black beads suckauhock, or black money. In addition to the quahog, the whelk (*Buccinum*) and the 'periwinkle' or 'winkle' (*Fulgur*) were used, the long, white columella being cut from the shell and made into beads. We learn from some of the older records that in Massachusetts the wampum was valued at three beads to a penny, or five shillings for a fathom. The fathom varied in size according to the number of beads allowed by law as an equivalent for a penny. If this number was six, then the fathom contained three hundred and sixty beads; but if the number was four, then the fathom was composed of two hundred and forty beads. Owing to the counterfeiting of wampum by the whites, who could make it much more quickly with their tools than could the Indians, the value rapidly fell in later years, and its use was finally discontinued.



Primitive money made from shells. 1. Wampum of Indians of the New England states. 2. Hai-kwa, made of Dentalium shells, coast of California. 3. Hawock of Pacific coast Indians, made from shell of Pachydesma. 4. Uhl-lo, or Haliotis money, made in the form of a crenulated disk. 5. Hawock, made from curved pieces of shell. 6. Kol-kol, or Olivella shell money. 7. Uhl-lo, made from Haliotis. (After Stearns.)

"On the coast of California, the tooth or tusk shells (*Dentalium*) were used as money, they being strung together as were the beads of the New England Indians. Those of the better quality were called hai-kwa or hi-qua, and represented the highest standard of money. One hi-qua would purchase one male or two female slaves. The damaged or defective shells were called kop-kops, forty of which equaled one hi-qua in value. At one time a single hi-qua was equal in value to about two hundred and fifty dollars. Other shells were also used on the Pacific coast. Some of these were simply strung in the form of beads, while others were

cut from large shells. One of the latter was from the large clam, *Pachydesma crassatelloides*, and the pieces were called hawock or ha-wok, their value ranging from four to twenty-five cents. Another clam used was *Saxidomus aratus*. The little *Olivella biplicata* was used as beads and called kol-kol. They were made by grinding off the apex, which left a hole through the axis of the shell. The *Haliotis*, or abalone, was also used and was called uhl-lo. Pieces of the shell from one to two inches in length were cut from the flat part of the abalone, holes were drilled at one end, and they were strung like beads. Their value was one dollar each, or ten dollars for a string of ten pieces.

"Like the shell money of New England, that of the Pacific coast was counterfeited by the whites, and for this reason, the value of the native currency soon declined.

THE ROCK SHELLS

"The rock shells, belonging to the genus *Murex*, are among the most beautiful and interesting of all the mollusks, and are a favorite among collectors. Their peculiar spiny shells and brilliant colors caused them to be among the first mollusks studied by naturalists, and we therefore find them described in the earliest works on natural history.

Venus comb. Murex tenuispina, which lives in China. (Woodward.)

"There are about two hundred kinds of rock shells, mostly confined to the tropical and subtropical seas, although a few are found in temperate climes. The largest number of these are found about rocks at low water, but not a few are inhabitants of waters as deep as five hundred or more fathoms. In our own country they are abundant along the coast of Panama, the Gulf of California, Florida, and the islands of the West Indies; but the greatest number of varieties come from the Indian Ocean, Japan, Australia, and the Philippines. The more brightly colored species are from tropical seas, while the dull, plain species are from subtropical and temperate climes.

"The murices are peculiar in having their shells ornamented by numerous projections, which vary from long, needle-like spines to simple fluted frills. What these spines and frills are for, would probably puzzle the ordinary observer, as they appear at first sight to be in the way. In some cases they may be simply ornamental, but in the main they are protective, and enable the mollusk to escape from being eaten by

some voracious fish. This is known as protective adaptation, and was doubtless brought about in the following manner:

"The murices or their ancestors did not at first have spiny shells, and they fell an easy prey to the fishes. As time went on, a few individuals, through some modification of their environment, developed small spines or prominences. The animals having these were not eaten by fishes, as the knobs and spines caused them pain in swallowing; therefore they preferred the animals with smoother shells. In time, this modification caused a weeding-out process, the animals without spines being exterminated, and those with spiny shells increasing in number and becoming more spiny as one generation succeeded another. This continued until the present time, and is going on even now. Another interesting fact concerning the development of this ornamentation is that the smoother shells inhabit rocky shores on which the waves are beating with greater or lesser violence, while the more spiny individuals live in protected and comparatively still waters. This but adds additional weight to the theory of survival by protection, for the fishes which feed upon these shells do not, as a rule, inhabit localities where the water is rough, as along a rocky shore, but live abundantly in protected bays and lagoons in which the spiny murices are found.

"One of the most beautiful of the rock shells is the Venus comb, found in China, Japan, and the Indian Ocean. It belongs to a group of shells which is characterized by a long canal and long, pointed spines which extend along the edge of the canal like the teeth of a comb, whence the name. The colors are yellowish or whitish, and in one species the spines are tipped with black. Another rock shell which is found on the mantel of almost every household is known as the branched rock shell, *Murex ramosus*. This mollusk is found in the Red Sea, the Indian Ocean, New Zealand, Australia, and the Central Pacific Ocean. It attains a large size, some specimens reaching the length of a foot and weighing several pounds. The aperture is frequently tinged with a deep, beautiful pink. In many households the large shells of this species are used as flower-pots, suspended over the window by chains, and for this purpose they are certainly very ornamental.

"The apple rock shell, *Murex pomum*, is of home production, being found on the shores of Florida and throughout the West Indies. It is not as attractive as the shell I have just mentioned, but is very common, every collector having several specimens in his cabinet. The horned rock shell, *Murex axicornis*, and the burnt rock shell, *Murex adustus*, are interesting members of this family. The latter name,

which signifies burned, is well chosen, for all of its spines and frills and most of the shell are black in color, and look just as though the shell had been scorched.

"A common rock shell found in the Mediterranean Sea, as well as on the coast of France and Portugal and in the Canary Islands, is the purple rock shell, *Murex trunculus*. It is a light brown, three-banded shell, about two inches in length, and is famous as having been used by the ancients in obtaining their rich purple dye. On the Tyrian shore, the shells were pounded in caldron-shaped holes in the rocks, and the animals were taken out and squeezed for the dye which they secrete. The fluid obtained was mixed with five or six times its bulk of water, and twenty ounces of soda were added to each hundred pounds of this mixture. It was then placed in lead or tin vessels, and exposed to the sun for several days until the proper hue was obtained. The wool was placed in this dye for a few hours. It is recorded that the dyed wool was valued at two hundred dollars per pound. A legend in Italy states that the discovery of this purple dye was due to the pet dog of a Tyrian nymph, which took one of these shells in its mouth and crushed it with its teeth, thereby staining its mouth and lips with purple. If the animal of one of our common *Purpuras*, a small shell found along the Atlantic and Pacific coasts, be squeezed, it will exude a purple fluid which will stain fabrics a reddish color. It is probable that much, if not most, of the royal purple of the ancients was obtained from these lowly creatures.

Purpura lapillus, a purple shell found abundantly along the Atlantic coast of the United States and Europe. (Tryon.)

"Although the most beautiful shells of this family are supposed to live in the warm, tropical seas of the Indian Ocean, it is nevertheless true that many of the most brightly colored rock shells live in the warm waters of Panama and west Mexico. The root rock shell, *Murex radix*, one of these shells, attains a length of five inches and is very heavy. The shell is white or yellowish white, and the spines and frills are jet black, the two colors producing a peculiar effect. Another beautiful shell from the same locality is the two colored rock shell, *Murex bicolor*, a shell attaining somewhat larger dimensions than the last. In this species, the spines are reduced to mere knobs; there are but few frills and only two colors, the outside being greenish white, and the aperture a deep red or pink, plainly showing the origin of the name, two colored. This shell is collected at Panama by thousands and shipped all over the United States, to curiosity stores, summer watering places, and

other vacation resorts, where they are sold at prices varying from a few cents to a dollar each, according to quality.

"Another rock shell, *Murex erinaceus*, is the cause of much damage to the oyster beds of Europe. It is assiduously hunted by the fishermen, who kill vast numbers by cutting off the foot and the operculum, after which the animal is allowed to die. The *Murex* kills the oyster by boring a hole in the apex, in the same manner as the drill, which is also a member of this family. The *Murex* family also includes the purple shells (*Purpura*), which are handsome shells found in many parts of the world; the castor-oil shells (*Ricinula*), which live in the warm seas of the Indian, Pacific, and Atlantic oceans, and the unicorn shell (*Monoceros*), which lives on the coast of California. It is remarkable for the presence of a long, sharp tooth on the lower edge of the outer lip, whence the Greek name, *Monoceros*, signifying one horn. These, as well as others of the family, are very interesting shells, as you will find when you study them more fully."

A castor-oil shell. Ricinula ricinus. which lives in China. (Woodward.)

The Professor ceased speaking, and as we assured him of our appreciation of his efforts in our behalf, we arose from our seats, intending to leave him, lest we should presume too much upon his kindness and willingness to assist us; but the rain came down more heavily, and the Professor urged us to remain. "If you are not too tired," said he, "resume your seats, and we will proceed with this fascinating subject, and I will give you a little talk on marine snails. If you find them half as interesting as they seem to me, another hour will pass rapidly, and by that time I think the storm will be over."

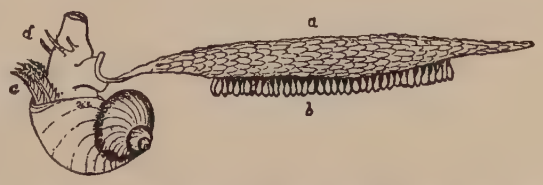
FROM COL. CHI. ACAD. SCIENCES.

MARINE SHELLS.

Cypraea pantherina (Red Sea)
Cassis flammea (Bahamas)
Conus marmoreus (Polynesia)
Buccinum undatum (U. S.)
Tritonium olearium (Naples)
Fasciolaria distans (U. S.)
Oliva irisans (Amboina)
Ianthina communis (Atlantic Ocean)
Voluta musica (West Indies)
Chiton squamosus (Jamaica)
Lottia gigantea (California)
Nassa glans (Amboina)

CONES, BASKET-SHELLS, AND OTHER MARINE SNAILS

"One of the most abundant of mollusks," began the Professor, "is the violet sea snail (*Janthina*), which spends its whole life floating on the waters of the Atlantic and Pacific oceans. The shell is very delicate, resembling in form some of the land snails, and has but two colors, both being shades of violet, a deep color on the under side, which is always turned upwards when the animal is in the water, and a lighter shade on the upper side. So fragile is the shell that it seems as if a breath could break it. The most interesting fact in connection with this mollusk is the wonderful float, or "raft," which is secreted by the foot, and to the under side of which the eggs are attached. The latter are not all in the same condition; those nearest the animal are more or less fresh; those in the middle of the float contain embryos and fully formed young, while those on the outer end are empty, the young having escaped into the water. The snails are gregarious, and may be found in countless numbers in various parts of the ocean. During a severe storm they are sometimes cast up on the beach in vast quantities, where they soon die under the fierce rays of the sun, or else fall a prey to various species of birds.



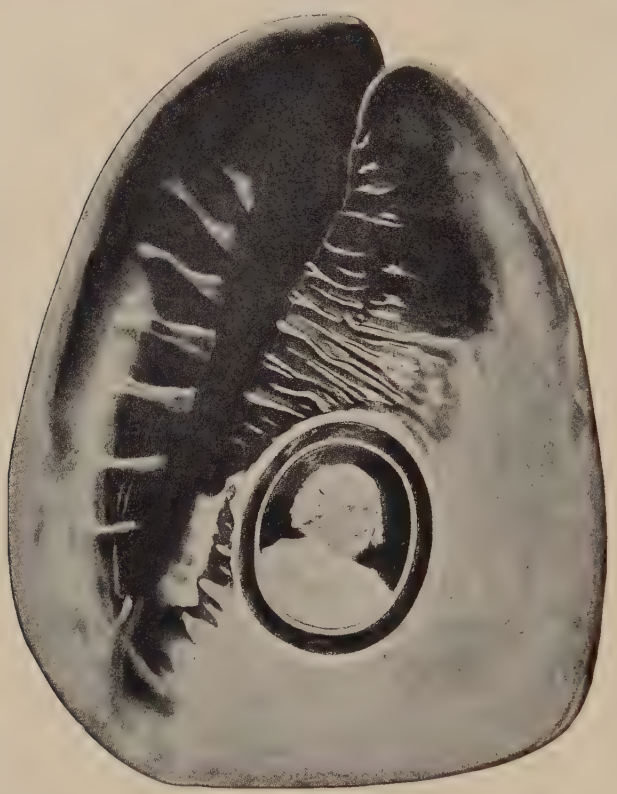
The violet sea snail, Janthina fragilis, with the animal and egg-float in their natural positions. a, float; b, eggs; c, gills, or breathing organs; d, head with the tentacles. (Tryon.)

"A handsome group of shells, which is related to *Janthina*, is the genus *Scala* — the ladder-shells or wentle traps. These snails are found in all parts of the world, on rocky or sandy shores, below the low-water mark. The shells are nearly always pure white, and they receive their name of ladder-shells from the regular series of longitudinal ribs which mark the whorls The large Chinese wentle trap, *Scala pretiosum*, was once very highly prized, and most extravagant prices were paid for specimens. It is recorded that on account of its

seeming rarity, the Chinese made quite perfect imitations of the shell with rice. Specimens may now be purchased for a dollar or two each.

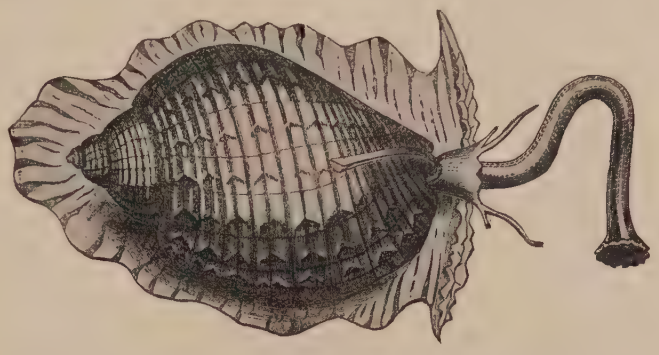
"The helmet, or cameo shells, are among the largest of sea snails, some of the specimens measuring eight or ten inches in length and weighing several pounds. They live only in comparatively shallow water, on sandy bottoms of tropical or subtropical seas; they are voracious eaters, living principally upon bivalve mollusks. The animal is large, and is remarkable for the extreme length of its proboscis.

"Cameos are frequently quite popular, both as ornaments for the person and as articles of bric-à-brac. Many of the best shell cameos are made from the helmet shells, which are well adapted to this purpose, owing to the different colored layers of the shell and their various degrees of hardness, making a bas-relief figure not only possible, but very effective. The word cameo is from the Arabic, and means anything in bas-relief. The name was once restricted to stone reliefs, but it now includes anything cut from stones or shells. The black helmet shell, *Cassis tuberosa*, is most frequently used, the figure being carved upon the white outer layer of the shell, which stands very clearly against the black background of the second layer. When a cameo is desired simply as a brooch, or for any other form of personal adornment, a piece of the shell is cut out and shaped into the required form and size, and cemented to a block of wood. The figure is then traced on the shell with a pencil, and finally worked out carefully with sharp pointed steel instruments of delicate size and form. The



Sardonyx helmet shell (Cassis tuberosa) with portrait of Columbus cut in bas-relief. Carved by E. Campi, of Rome, one of the foremost artists of cameo work. (Kunz, Bull. Fish. Com., 1893.)

same process is resorted to in working out a bas-relief on the entire shell, the latter being placed in a vise to hold it firmly. The home of this industry is at Genoa and Rome, Italy, and for a long time the practice of the art was confined to that country. At the present time it has spread to France, and in Paris alone several thousand people are employed at this work, although the product is not of as fine a quality as is that from Italy. Many beautiful examples of these cameos were exhibited in Chicago, in 1893, at the World's Columbian Exposition.



Tun shell, Dolium perdix, showing the wide, spreading foot, long proboscis, small tentacles, and thin shell. (Woodward.)

"A genus related to the helmet shells, but thinner and more delicate, is the *Dolium*, or tun shell, which is often beautifully colored and delicately sculptured. The animals of the fig shells, a related genus, are very timid, but when undisturbed are also very lively, crawling over the ground with great rapidity. When in motion, the long, tapering tentacles are fully extended, and the siphon is directed almost straight ahead, instead of over the back, as in many other snails. The colors of the animals vie with those of the shells, their bodies being marbled with violet and pink, and with spots of white here and there. The large, black eyes are very conspicuous. The foot and mantle are so large that the shell is frequently almost buried from sight. There are ten species of fig shells, and they may be found in the warm waters of the West Indies, the Philippine Islands, and the west coast of central America. One fine species, *Pyrula papyratia*, lives in Florida, where it may be collected in large numbers.

"Probably no more distinct family of mollusks exists than the *Conidæ*, or the family of cones, their beautifully decorated shells and the large number of species making them a favorite group with collectors. The shell is in the form of an inverted cone and gracefully rounded, the aperture being but a narrow slit extending nearly the whole length of the shell. The colors of the cones are always very brilliant, although when they are alive the shell is not so highly polished as that of the *Cypræas*, owing to the presence of a horny epidermis. About three hundred species of cones are known; these live

principally in tropical seas, where they love to conceal themselves in holes in the rocks, or among the branches of corals. The animal is predaceous, boring into the shells of other mollusks and extracting the juices from their bodies. The teeth of *Conus* are hollow and very sharp, and have a barb on the end. A poison gland is said to be present, and bites from the animal are very painful, although not dangerous; yet the large *Conus marmoreus* is able to inflict a severe wound. The cone is quite pugnacious, and when picked up will immediately bite the hand. It is a veritable reptile of the ocean.

The textile cone, Conus textile, which lives in the Philippine Islands. (Tryon.)

"Mr. Arthur Adams records the case of a gentleman who was collecting on the shores of the Moluccas. He had taken a large cone shell from the water, and was much surprised to have it suddenly thrust out its proboscis and bite his hand. The bite left a small, deep, triangular mark, which was followed by a watery vesicle. The gentleman described the sensation to be like that caused by burning phosphorus under the skin. The moral of this story is, 'Be careful in picking up individuals of the cone family.' A fine chestnut colored cone lives on the coast of California; and several species, notably *Conus proteus*, with reddish brown spots on a whitish ground, may be collected in Florida. The great majority of the species are found in the Pacific and Indian oceans.

"A very large family of shells nearly related to the *Conus* is the *Pleurotomidæ*. The name is from the Greek, and means side notch, and is given to these shells because of the peculiar notch or sinus in the upper part of the outer lip. There are over five hundred species in this family, all having shells which are fusiform and turriculated, and with long spires and canals. They live in all parts of the world, and may be found from low water to a depth of over a thousand fathoms. Some of the species are very large, being over four inches in length, while others are less than one-fourth of an inch in length. All are handsomely sculptured with spiral lines and pustules.

Pleurotoma babylonia. (Tryon.)

"The *Columbellas*, or dove shells, are among the most common mollusks found on the shores of tropical and subtropical lands. Their shells are never large, scarcely exceeding three-fourths

of an inch in length, and are oval and solid. They are of various colors — brownish, whitish, yellowish, and reddish, variously spotted with white, red, and black. There are three hundred species of these shells, the majority of which live on the rocks and corals, at low-water mark.

"On the sandy shores of subtropical beaches certain animals with graceful and polished shells, bury themselves from sight in the sand. These are the olive or rice shells, *Oliva*, whose bright colors and highly polished surfaces rival even the gaudy *Conus* and *Cypræa* in beauty. The foot may be described as plow-shaped, and is admirably adapted for digging rapidly in the sand, enabling the animal to quickly hide from sight on the approach of enemies. The long siphon is thrust up through the canal in the anterior part of the shell, and its end protrudes through the sand. The high polish of the surface is due to the voluminous folds of the foot which envelop the shell, hence there is no epidermis. Unlike the *Cypræa*, which covers its shell with a glossy coating only upon reaching maturity, the *Oliva* produces the shiny layer at all periods of its life, the three strata being deposited simultaneously. It is like *Cypræa*, however, in dissolving the inner whorls to a paper-like thinness to accommodate its constantly increasing size. The aperture is so narrow that it is difficult to understand how the animal gets in and out. In many places the olive shells are very numerous, and may be seen crawling rapidly over the beaches when the tide is out. It is recorded that a species living at Panama, *Oliva volutella*, has its body covered with sand, and when the first incoming wave of the returning tide washes off this coat of sand, it buries itself from sight and does not crawl about again until the succeeding ebb of the tide. There are about ninety species of olive shells.

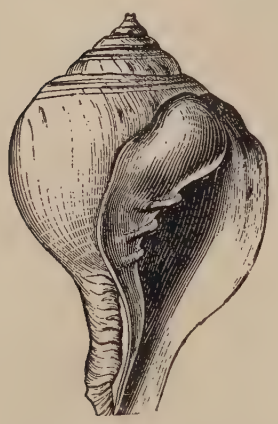
A maiden shell, Ancilla glabrata, a common shell of the West Indies. (Tryon.)

"Closely related to the olive shells are the *Ancillas*, or maiden shells. Their polished yellowish, whitish, or brownish shells are fully as attractive as those of the olives. Unlike the latter, their spires are rather long, and some of the species have a large umbilicus. They live in the Red Sea, Indian Ocean, Australia, Japan, and the West Indies.

"A neat genus of small shells allied to *Oliva* is *Marginella*, comprising about two hundred species, which are found in tropical and subtropical seas. The shells are brilliantly polished, and the animals are similar in habits to the olives.

"Of the many varieties of tropical shells few exceed the *Volutes*, or bat shells, in beauty or variety of coloration. They are found in most parts of the world, although strangely enough none are now living in the seas of Europe, but they are most abundant and more highly colored in the tropics and subtropics. The animal is carnivorous, and the long, fang-shaped teeth are certainly suggestive of predaceous habits. The shell is ovate, thick, and solid, and variously colored, some being mottled, some with zigzag, or lightning-like markings, while others have spirally arranged dots, dashes, and lines. Australia is the metropolis of this family, and it is said that eighty per cent of the species are found in the triangular area bordered by Ceylon, Japan, and New Zealand. The genus is supposed to be oviparous in producing its young. One species, *Voluta musica*, has received its name from a more or less fancied resemblance of the surface of the shell to a musical staff, the spiral lines being grouped in sets of four or five, and the dots being arranged as notes. In some shells the resemblance is quite close. The smooth and polished shell is due to the reflected lobes of the foot.

"The related genera *Cymbium* and *Melo*, the boat shell and melon shell, are common on the coasts of Africa, Australia, and in the Pacific Ocean. They sometimes reach the length of a foot. The shells are ovate and very ventricose, although not especially solid or heavy, like the *Volutes*. The nucleus or apex is very large, as is that of other species of this family.



The shankh of the Hindoos. Turbinella pyrum. (Tryon.)

The shells of a closely related family, *Turbinellidæ*, are used in India to make rings and bangles which the native women wear, many of them being beautifully painted. One species of this family, the *Turbinella pyrum*, is a sacred shell to the Hindoos, by whom it is called shankh or chank; it is the national emblem of the province of Travancore.

"The basket shells, or dog whelks (*Nassa*), are among the most numerous in individuals of all the marine shells, the common black whelk, *Nassa obsoleta*, being the most common of all the mollusks. At times a mud flat at low water will be literally paved with the shells of this snail, there being millions of the little creatures crawling about. The shells of this family are frequently very handsome, being latticed by the crossing of spiral and longitudinal lines. They are mostly of small size, seldom exceed-

ing an inch in length, many of them being much under this dimension. The animal is very rapid in movement, and leaves a distinct track in the mud, which will frequently end at a little pellet of mud, which upon examination will disclose the little animal nicely concealed beneath. In the water the animal is exceedingly active, gliding about easily with its long, tail-like foot. It may be frequently seen with the foot applied to the under side of the surface of the water, the shell hanging downward, as has been observed in the pond snails. There are about one hundred and thirty species of *Nassa*, which are found in all parts of the world. The genus is mostly littoral in habit, living between tides, or at low-water mark, but a few have been dredged at great depths. The name *Nassa* signifies a narrow-necked wicker basket, which is used for catching fish. The application of this name to these shells will be easily understood when once a reticulated specimen is examined. One species, the *Nassa mutabilis*, is used as food in Italy. The *Nassa* is one of the best molluscan scavengers known; but it is also a carnivorous animal, as the oysterman, whose beds it devastates, well knows. The *Nassas* of France, especially the *Nassa reticulata*, are very destructive to the oyster beds of that country, one adult "borer" being able to perforate the shell of an oyster in a single night. So numerous are these pests that a single acre has yielded over a thousand individuals. Should our native *Nassa obsoleta*, of which a thousand individuals could be found in an area five feet square, change its diet from dead fish to oysters, an oysterman would be compelled to go into bankruptcy, ruined by the basket shells. As a result of the depredations to the French beds, the oystermen carry on a relentless war against the *Nassa*, destroying many thousands annually. But with all this persecution the mollusk still exists and increases in numbers. The dead shells of this genus are a favorite home for the hermit crab of small size, and it is suspected that sometimes other than dead shells are appropriated. We fear that a sort of piracy is resorted to by the hermit crab, resulting in a kind of 'walk-the-plank' end for the mollusk, before the new tenant takes possession of the home.

A basket shell, with the animal in locomotion. (Tryon.)

"A genus of mollusks, with light horn colored shells, and inhabiting the cold waters of the arctic seas, is the *Buccinum*, or whelk. In various parts of Great Britain it is known as 'buckie' and 'mutlog.' The *Buccinum* delights to burrow in the sand, like the moon shells (*Natica*), and frequently nothing but the end of the siphon can be

seen, the latter protruding from the sand to enable the water to enter the animal and furnish the necessary oxygen for its gills. The whelk is used economically for both food and bait. One ingenious method of catching them is to fasten a dead fish of good size to a wire basket, and allow it to rest on the bottom for a short time; when taken up, it is sure to be covered with large, fat whelks. This fishery in Great Britain is fully as valuable as our oyster fishery, the annual income from this industry reaching to thousands of pounds sterling. The animal is also one of the principal baits used in cod-fishing. A related genus of shells (*Chrysodomus*) is also eaten by the poorer people, and likewise makes a good codfish bait. The two kinds of whelk, *Buccinum* and *Chrysodomus*, are called respectively, the white whelk and the red, or almond whelk, probably on account of the color of the two shells. In the Shetland Islands the red whelk is used as a lamp, being suspended by strings from a nail, the mouth placed uppermost and filled with oil.

The black whelk, Chrysodomus antiquus. (Tryon.)

"The family *Buccinidæ*, of which the whelks belong to the typical genus, include a great variety of differently shaped shells, living in all parts of the world. Some of these are brilliantly colored, like the *Eburnea;* while others, like the *Buccinum*, are perfectly plain. Several large and handsome shells live in Florida; one, *Melongena corona*, having the spire ornamented with many spines; while another, the *Fulgur*, or lightning shell, is pear-shaped, and attains a length of eight inches. In various parts of the Southern states this species is largely used in making borders around flower-beds and in lining walks. It is also used as a flower-pot, and the aborigines utilized it in making wampum, tools, and even drinking-vessels. The handsomest species of this family belong to the genus *Eburnea*, the ivory shells. They have rather large, smooth, rounded shells, the polished surface being marked by spots of reddish. They are very abundant in the Indian and Pacific oceans.

Melongena corona, a common Florida marine snail. (Tryon.)

"One of the most graceful of all the marine shells is the *Fusus*, belonging to the family *Fusidæ*, and comprising mollusks with long, spindle-shaped shells, high, turreted spires, and long canals. They are found throughout the tropical and subtropical regions of the

world, although a few species are found in temperate and in arctic climes. A related genus, *Fasciolaria*, or banded snails, is a familiar object to those who visit Florida. The *Fasciolaria distans* attains a length of three inches, and is very prettily banded with narrow stripes. A near relative of this species is the giant banded shell, *Fasciolaria gigantea*, the largest of all marine snails, growing to a length of nearly two feet. This species is found on the southern coast of the United States, and is particularly abundant about the coral reefs of the Florida Keys.

"Among the best known of the marine snails are the *Tritons*, a family of mollusks living in the warm seas of the tropics. Their shells are generally large and highly colored, and are variously ornamented with short spines and knobs. Many of the species are covered with a hairy or bristly epidermis. This genus is remarkable for including in its hundred or more species almost the largest and smallest of marine gastropods, ranging from one-fourth of an inch to eighteen inches in length. The *Tritonium tritonis*, or trumpet shell, which attains the largest length, is one of the handsomest and most striking of shells. In the vicinity of the Loo Choo Islands it is said to be used as a tea-kettle, the operculum forming an excellent lid, the whole apparatus being suspended over the fire by a wooden peg. The frog shells, *Gyrineum*, are related to the *Tritons*, but the animal is more active. Some of the shells have long, sharp spines, while in others the whorls are simply foliated. Both *Tritonium* and *Gyrineum* have the shell marked by distinct varices, like the genus *Murex*."

Tritonium tritonis, the trumpet shell. (Tryon.)

Professor Parker then rose from his seat, and called our attention to a number of marine shells which he had purchased to add to his collection in the West.

Dendronotus arborescens, a nudibranch, or sea slug. Note the tree-like aspect of the branchiæ, or breathing organs, which project from the back. (Woodward.)

"I have now told you of a number of the most interesting and best known families of marine shells," he added, "but these include but a very small part of these animals which live in the sea. There are thousands of species of minute mollusks which live among the marine vegetation and in the mud on the bottom, and some are even parasitic or commensal on other animals,

as the little *Stylifer*, which lives on the spines of sea urchins and star-fishes. A whole order, the *Nudibranchiata*, or sea slugs, are destitute of a shell, although possessing calcareous spicules, or spines in the skin, which serve to make the body rigid. The breathing organs, or branchiæ, are placed on the outside of the animal, near the posterior part of the body, and look like leaves. The animals are also brilliantly colored. Another order, the *Pteropoda*, is composed of mollusks called sea butterflies, on account of the two swimming lobes, which are incessantly moving. The shells are of various shapes and sizes, glassy, thin, and transparent. These animals are pelagic; that is, live always in the ocean, and never approach land unless driven in by a storm. They feed on microscopic animals, and are in turn eaten by whales and fishes."

Hyalæa trispinosa, a common sea butterfly, or pteropod. Note the two swimming lobes, or "wings," from which the order receives its name. (Tryon.)

After spending some little time examining his new collection of marine shells, we bade the Professor good by, he promising in the near future to allow us to accompany him on a collecting trip.

A poor collecting locality.

IN SEARCH OF THE SQUID

One afternoon Professor Parker announced to us that he was going to visit the fishermen's weirs in the river near the little town of Warren, for the purpose of obtaining some large specimens of the squid, and he invited us to go with him. We accepted his kind invitation, and were soon ready to board the train for Warren. A short ride of ten miles brought us to our destination, where we spent the night. The next morning the Professor awoke us quite early. After eating a hearty breakfast, we walked to the wharf, and found the fishermen ready to

Fishermen's Weirs. (U. S. Fish. Com. Report, 1898.)

visit the weirs. Hastily scrambling on board one of the boats, we were soon being rowed up the river toward the fishing-grounds. The wind was blowing rather briskly, and the water was so rough that Howard came very near being seasick; but as we advanced farther up the river, the water became a little smoother and our position more comfortable, although we were wet with the spray, and were visibly shivering. This greatly amused the fishermen, who were sturdy fellows, toughened by years of exposure to wind and rain, and who did not mind such weather at all.

The river where the weirs were located widened into a bay more than

a mile across. After we reached the weirs, the fishermen began to draw up one net, and what a commotion set in when it had been pulled up a little way! Fishes were jumping, a sting ray and a horse-foot crab were floundering about, and the net seemed to be fairly alive with soft-shelled crabs. Suddenly Professor Parker called us to look at the net, at the same time pointing his finger into the water. Our eyes followed the direction in which his finger was pointed, and saw several long, cylindrical objects which were darting here and there in the water. These, he said, were the squids.

Soon after this, Howard stooped and quickly seized an object which seemed to have become entangled in the net. It was a squid in trouble, and Howard's face was brought so near the animal that our instructor cautioned him to be careful, as the squid might shoot at his eyes. Professor Parker had hardly spoken, when the water about the animal became inky black, and a stream of black fluid shot up toward Howard's face, compelling him to let go of the squid, with a cry of surprise. The animal had emptied the contents of its ink bag in a vain endeavor to escape. We immediately questioned the Professor in regard to this curious habit of the squid, and were told that this was one of nature's ways of protecting it from its enemies; that the ink bag was quite large, and was placed near the base of the siphon, and that when the squid was aware that an enemy was near, it discharged the inky contents of this bag through the siphon, and while the water was black and muddy from the effect of the ink, it swiftly swam away, and so escaped. We were also told that it is thought by some scientists that this inky discharge is as much for disconcerting the enemy as for rendering the animal invisible, and that the ink bag is a very characteristic organ in this class of animals.

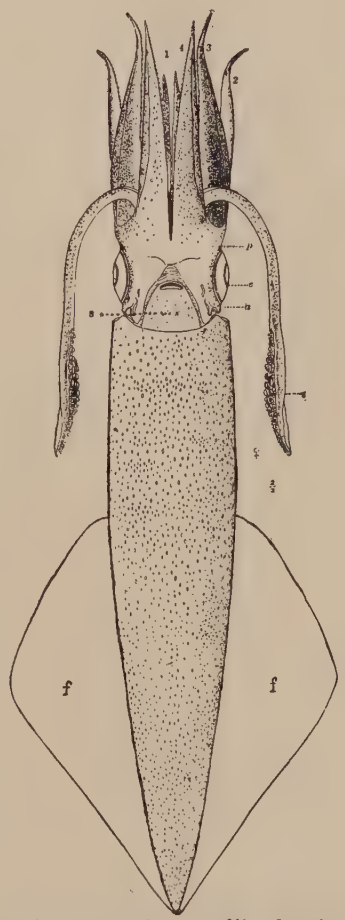
Howard was a most enthusiastic investigator, and as a result, he was often getting into trouble because of his impetuosity. Once his hand was seized by an angry squid as he tried to grab it, while it lay near the surface of the water. One of the fishermen extricated his hand, and the Professor told him that he should be careful not to get near the arms of any of the squid family, because each arm was covered on the inner side with many little suckers which would hold an object tightly while the squid bit out pieces of the flesh with its parrot-like beak.

The Professor had brought with him a large copper can with a wide mouth, which was half-filled with a sixty per cent solution of alcohol, and which he proceeded to fill with squids and soft-shelled crabs.

After spending a couple of hours or more in examining the weirs, in each of which we found some fishes, squids, and crabs, we returned

to the town, and Professor Parker asked us to help him prepare the specimens. Upon reaching his room, he procured a large tub, and emptied the contents of the copper can into it. Thoroughly washing out the can, he filled it two-thirds full of seventy-five per cent alcohol, and then told us that he was ready for work.

Picking up a specimen of the squid about a foot long, he proceeded to show us the different parts of the animal, and to describe their functions. The body was long and cylindrical, and was divided into two parts: the body proper, which resembled a conical sac, open at one end and sharply pointed at the other, to which two broad fins were attached; and the head, to which the arms, or feelers, were attached. The head was somewhat movable, and had a large eye on each side. The arms were ten in number, eight being short and thick, and lined on the inside with several rows of round, cup-shaped sucking disks. Two of the arms were very much longer than the others, and were slender and cylindrical, excepting near the end, where they were enlarged to form an oval club, the inside of which was covered with suckers. The little suckers, or acetabula, were examined with great interest. Each one was a rounded cup, the rim of which supported a horny ring with serrated or teeth-like edges. The sucker was attached to the arm by a slender peduncle, or stem. Inside the cup there was a shallow cavity, and at the bottom a small, flat piston. The sucking action is produced in the following manner: when the sucker comes in contact with any object, the piston, which is made up of strong muscles, is pulled back, thus forming a vacuum in the cup which causes the latter to adhere firmly to the object. It may be easily seen that a squid has tremendous holding power when several hundred of these suckers are in action.

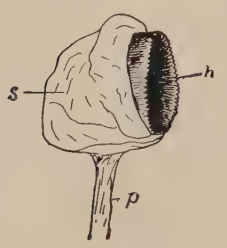


Squid, Loligo pealii, showing different parts of body. a, ear; e, eye; f, fins; p, water pore; s, siphon; t, tentacular arm; 1, 2, 3, 4, the short or sessile arms. (Verrill.)

We saw that the mouth was placed in the center of the head where all of the arms join, and that it was armed with a horny beak like that of a parrot, only inverted. With this beak the squid is able to bite off pieces

of flesh which are then further cut up by the little teeth on the tongue, or radula, which are placed farther back in the mouth.

The eyes were large and wonderfully developed, and the Professor said they were almost as complicated as the human eye, being made up of cornea, retina, iris, pupil, and optic nerve. Just back of the eye, the ear, or auditory organ, was placed, and was represented by a curved fold in the head.



Sucker of squid. h, horny ring surrounding aperture; p, pedicel, or stem; s, cup of sucker.

The siphon was a conspicuous object, and was placed on the lower or ventral side of the animal. It was more or less conical in shape, and bent a little outward toward the ventral surface. The aperture was oval and large, and was provided with a valve to govern the flow of water.

Professor Parker said that the siphon is a valuable organ to the animal, for it not only brings fresh water to the gills, but by forcing water violently through it, also serves as an organ of locomotion, enabling the squid to shoot backwards very rapidly.

The Professor next called our attention to certain small, dark brown spots which covered the surface of the body and head. These he called chromatophores, or pigment spots. Some of these spots were oval, while others were irregular in outline, with many radiating lines running into the surrounding parts of the body. In the living animal, these little pigment spots, or cells, are constantly swelling until the different spots touch each other, and then contracting until they are scarcely visible. The cells contain different colored pigments, and the effect of these changes is to cause waves or blushes of different colors to sweep over the animal. The possession of this power of changing color is a great protection to the animal, for it is able to become the color of many objects upon which it may be resting, and thus be rendered inconspicuous. This is called protective coloration, and a similar power is possessed by other animals, such as the chameleon, so common in Florida. In the octopus the changes are more varied than in the squid, owing to its more sedentary habits.

Beak of squid. Upper and lower mandibles in natural position.

George inquired of the Professor whether the squid had a shell. For answer he turned back a flap which projected over the head from the upper or dorsal side of the squid, slit the thin skin of its inner surface, and pulled out a long, thin, horny object, which he said was the internal shell, or pen, of the animal, and served to support it in somewhat the

same manner as does the backbone in vertebrate animals. The pen was nearly a foot in length, and much resembled a quill or bird's feather, from which it receives its name. It is formed of a stout central shaft, which reaches nearly to the lower end, and has a thin blade on each side. It lies in a pocket, or capsule, in the dorsal side of the squid, but is not attached to it by any muscles. The octopus does not have this internal skeleton, because it lives about rocks and on the bottom of the sea, while the squid and cuttlefish are pelagic, or free swimmers, and therefore need some sort of support for their soft bodies.

Pen, or internal support of squid. Notice the long, narrow, central shaft, and the wide margin on each side. (Verrill.)

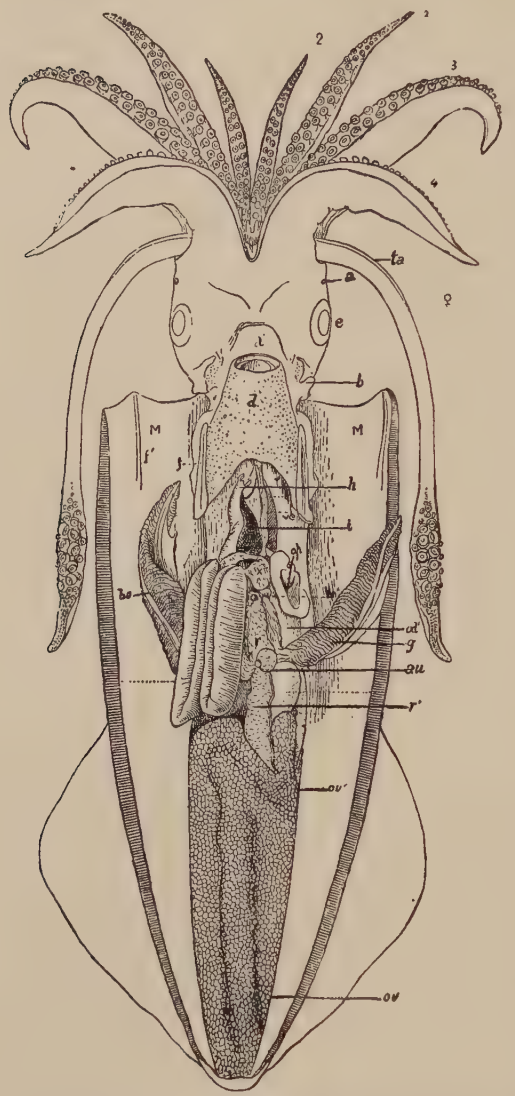
Procuring a pan of water, Professor Parker immersed a large squid, cut the skin or mantle from the upper edge or collar to the pointed posterior end, turned back the several pieces, and exhibited to us the internal organs. We saw that the mantle was attached to the head in three places by a set of cartilages, those on the mantle fitting into those on the head like a long and narrow button and button-hole. One cartilage was on the upper or dorsal side, in the center, and two were on the ventral side on the siphon.

We were told that the inside of the animal is called the mantle cavity, and we were shown that it contains the heart, gills, nervous system, digestive system, and all of the vital organs. We found the siphon to be made up of three chambers; a funnel-shaped ventral chamber opening into the mantle; and on either side a chamber which opens into the mantle chamber, but not on the outside. By this arrangement, Professor Parker said, the water contained in the mantle cavity is compelled to pass through the ventral chamber, as the lateral chambers, having no outlet, are forced against the sides of the mantle chamber, causing it to close; and thus the siphon is made an important organ of locomotion, for when the water is thus forced out, the animal shoots backward. Near the base of the siphon we saw the little oval ink bag. The large gills and venæ cavæ were the only organs which seemed to be attached to the mantle, and the posterior part of the body was made up of the large visceral sac, which contains the stomach, liver, and other organs.

Having learned what we could about the squid, we helped Professor Parker prepare the rest of the specimens. To do this, a slit was cut in the mantle, so that the liquid might reach the internal organs,

and then they were packed in the copper tank and covered with the alcohol.

As we expected to collect some specimens for our own cabinets to be preserved in alcohol, we carefully noted Professor Parker's method of packing the bottles in boxes for shipment to his home in the West. The bottles were first wrapped in papers, and then packed tightly in a large box, separated from each other by masses of tightly crumpled newspaper, of which a layer was also placed on the bottom, sides, and top. The Professor said that in some localities damp moss might be used in place of the paper. "The one essential object," said he, "is to pack the bottles so that they will not shake about. It is also best to put in the bottles a number stamped on block tin, corresponding to a number in your note-book, where all information concerning the specimens should be kept. If the tin is not procurable, the information may be written on stiff linen paper with a soft lead pencil. Never write with ink, or any writing fluid, and never use ordinary tin, for that will corrode. Dry shells may be packed loose in small boxes, and padded with cotton, moss, or even paper. Stiff paper rolled in the form of cylinders or cornucopias is also a safe method. Always write the full information or data on each bundle or box. In shipping specimens, several small packages, as small soap-boxes, will carry more safely than one large one."



Anatomy of squid, Loligo pealii, female. a, water pore; b, ear; au, branchial auricles; bo, blood-vessel in gill; d, siphon; f, cartilages of siphon; g, gill; h, intestine; i, ink bag; m, mantle; ov, ovary, or egg gland; od, oviduct, or canal through which the eggs are discharged into the water; op, opening of this canal; r, kidney, or renal organ; ta, tentacular arms. (Verrill.)

The specimens were all cleaned and packed by the middle of the afternoon, and the Professor suggested that we walk along the beach near the mouth of the river, as it was not far away. After a half-hour's walk we reached the desired point. The tide was at its lowest ebb, and the beach lay stretched before us, a mingled mass of rocks, seaweed, eel-grass, and sandy beach. The Professor told us that this spot was once famous as the home of the *Fulgur*, or winkle shell, and so it proved upon examination, for Harry and George each picked up a large *Fulgur canaliculatus* at the same time, and soon all members of the party had secured several good specimens. A couple of hours were spent along the shore, which resulted in the acquisition of about thirty species, several of which had not been collected before.

Late in the evening, we returned to Providence, anticipating a pleasant time on the following day, when we were to again visit the museum in Boston, for the purpose of studying the squid, nautilus, and other animals of this class.

THE NAUTILUS AND ITS RELATIVES

Year after year beheld the silent toil
That spread his lustrous coil;
Still, as the spiral grew
He left the past year's dwelling for the new,
Stole with soft step its shining archway through,
Built up its idle door,
Stretched in his last-found home and knew
The old no more.

— HOLMES, *The Chambered Nautilus.*

On the day following our excursion after squids, we again visited Boston in company with Professor Parker, and the entire day was spent in that city and in Cambridge, studying the specimens in the museums. From the Professor we obtained the following information concerning the various kinds of squids and their relatives.

The highest group of mollusks belongs to the class *Cephalopoda*, which signifies head-footed, the name having been given to them because the head is surrounded by a circle of tentacles which act as both arms and feet. The general plan of the animal is that of a sac, the head protruding from the anterior end, and ending, as before stated, in a circle of eight or ten arms. The eye is wonderfully developed, and the nervous system is very complex. As the brain is protected by a cartilaginous box, they resemble the vertebrate animals in this one respect. In this class, the majority of the species that possess shells are extinct, there being only from a dozen to fifteen species living at the present time. The *Ammonite* is an excellent example of the extinct *Cephalopods*.

The most familiar member of this family is the pearly nautilus, *Nautilus pompilius*, the shell of which may be found on the mantelpiece or what-not of many dwellings. The shell of the *Nautilus* is formed in a spiral and is made up of many chambers, all connected by a tube called a siphuncle. The outer chamber contains the animal, and is hence called the living chamber. This shell is called the pearly nautilus, but the pearly tints cannot be seen until the outer layer, which is yellowish white with brown markings, is taken off, when the exquisite, rainbow-

FROM COL. CHI. ACAD. SCIENCES.

COPYRIGHT 1901, BY A. W. MUMFORD, CHICAGO.

CEPHALOPODS.

Beak of Octopus.

Pearly Nautilus.
Nautilus umbilicatus (New Caledonia).

Paper Nautilus.
Argonauta tuberculata (Indian Ocean).

like colors may be observed. There are over three hundred fossil species of the *Nautilus*, and but five or six that are still living.

While the shell of the *Nautilus* is well known, the animal is very rare in our museums, although the natives of the Fiji Islands, the New Hebrides, and New Caledonia are able to obtain it in large quantities for food, and it is highly esteemed by them. During the voyage around the world of the English survey steamer Challenger, a living *Nautilus* was captured by dredging in about three hundred and twenty fathoms near Mateeka Island, one of the Fiji group. It was placed in a tub filled with water, in which it swam about in a lively manner by ejecting water from its funnel. The tentacles, of which there are a larger number than in the other *Cephalopods*, were spread out radially, like those of the sea anemones. Thirty-six of these tentacles may be retracted into eight pouches, which represent the eight arms of the *Octopus;* forty-eight are arranged about the mouth, and four, called the ocular tentacles, are placed on the head, one in front of, and one behind each eye. All of these tentacles are without suckers. A peculiar appendage, called the hood, is formed on the upper side of the pouches. This acts as an operculum, and closes the shell when

Pearly nautilus, Nautilus pompilius. The shell is cut in section and the animal is in its natural position in the shell. a, mantle; b, dorsal fold of mantle; c, nidamental gland; g, shell muscle; i, siphuncle connecting animal with chambers of shell; k, siphon or funnel; n, hood; p, tentacles; s, eye; x, septa or partitions separating chambers; z, last or living chamber. (From Woodward, after Owen.)

the animal retreats within it. The *Nautilus* also differs from the other *Cephalopods* in lacking the ink gland, and in possessing a simple eye, which is placed on a peduncle, or stalk, and is without cornea, lens, or vitreous humor. Although sometimes seen floating on the water in large schools, the natural habitat is on the bottom of the ocean or among the coral reefs, at depths ranging from three to three hundred fathoms or more, where it crawls about on its tentacles, the shell floating above. Their food is not definitely known, but it probably consists of crabs, as well as holothurians and other echinoderms.

The Fijian's method of capturing the *Nautilus* for food is thus described by Mr. Tryon in his Structural and Systematic Conchology: "When the water is smooth, so that the bottom, at several fathoms depth, near the border of the reef, may be distinctly seen, the fisherman in his little frail canoe, scrutinizes the sands and the coral masses below, to discover the animal in its favorite haunts. The experienced eye of the native may probably encounter it in its usual position, clinging to some prominent ledge, with the shell turned downwards.

"The tackle consists: first, of a large, round, wicker basket, shaped very much like a cage rat-trap, having an opening above, with a circlet of points directed inward, so as to permit of entry, but to preclude escape; secondly, a rough piece of rope of sufficient length to reach the bottom; and lastly, a small piece of branched wood, with the branches sharpened to form a sort of grapnel, to which a perforated stone is attached, answering the purpose of a sinker. The basket is now weighted with stones, well baited with boiled crayfish, and then dropped gently down near the victim. The trap is now either closely watched or a mark is placed upon the spot, and the fisherman pursues his avocation upon other parts of the reef until a certain period has elapsed, when he returns, and in all probability finds the *Nautilus* in his cage, feeding upon the bait. The grapnel is now carefully let down, and having entered the basket through an opening on top, a dextrous movement of the hand fixes one or more of the points or hooks, and the prize is safely hoisted into the canoe."

The animal is made into soup by some of the natives, while others eat it boiled. The shell is used by the natives to make beautifully carved figures, the contrast of the dark outer coating against the light, pearly shell producing a striking effect. In India the shell is used as a drinking-cup, and in Europe it is used to make elegant cameos, which are much sought and are highly prized as ornaments.

The argonaut, or "paper-sailor," is no less beautiful and interesting than the pearly nautilus. The thin and fragile shell cannot be com-

pared with that of the *Nautilus*, nor with the pen or internal support of the squid, for it is attached to the animal by no muscles, and is only kept in position by the broad webs on the upper arms of the female which alone possesses a shell, and its function is simply to protect the eggs. The male is very much smaller than the female, and is exceedingly rare. The female, when in natural position, has the arms spread out and hanging about the shell, four in front and four behind, and the two broad arms which support the shell are expanded and closely embrace it. The siphon is turned toward the ridged part of the shell, and the animal progresses in a backward direction by forcibly ejecting water through this organ. It crawls on the bottom of the sea with the shell on its back, like a snail. The argonaut shells are found in all warm seas.

The paper sailor, Argonauta argo, in its natural position when floating on the surface of the sea. (Tryon.)

The poets have given us many beautiful writings detailing the vices and virtues of the lower forms of life, and among these the pearly nautilus and the "paper sailor" have received a good share of the muse's attention. But the poet, not writing as a conchologist, sometimes mixes the relationships of these creatures, and we must not be misled, knowing that poetical license sometimes takes liberties with scientific facts.

Spirula lævis. The shell is shown as if seen through the mantle. (Woodward.)

The *Spirula* is a mollusk whose shell is cast up on the shore by thousands, but the animal of which is very rare. The shell is less than an inch in diameter, is made in the form of a loose spiral, and is divided into little chambers connected by a siphuncle. The shell of this genus does not contain the animal, as does the shell of the *Nautilus*, but it is enveloped in two flaps of the mantle, at the posterior part of the animal, and is concealed, with the exception of a part of its edge, on each side. The body of the animal is long and cylindrical, and the arms are quite short, more nearly resembling those of the *Nautilus* than those of the *Octopus*, or squid. The body ends in a disk, which is supposed to be a kind of sucker, by which the animal can adhere to rocks, thus enabling it to freely use its arms in obtaining food. It has been supposed by some anatomists that the shells of the fossil *Ammonites* were attached to the animal in a similar manner. If this can be shown to be true, these

small mollusks will assume a new meaning as being the last survivors of a large group of animals of which all except the *Spirula* are extinct.

Probably the best known of the shelless *Cephalopods* is the *Octopus*, with its rounded body, large eyes, and long arms.

The *Octopus* is found abundantly throughout temperate and tropical seas, generally near the coast among rocks, but frequently on the sandy bottom, in water of moderate depth. On the sandy bottoms it may occasionally be seen "walking" clumsily along on its eight long arms, its little round body being balanced above. It has been seen to use its dorsal pair of arms as the land snail does its tentacles. Its favorite position, however, is among the rocks. In such a locality it will squeeze its body into some cavity and spread out its arms until they form a sort of web, resembling, in this position, a huge spider waiting for its prey. And it may well be likened to a spider, for from this net there is no escape if the hapless fish has come in contact with the powerful suckers on the long arms. The poor fish is paralyzed when seized by the *Octopus*, and is drawn towards the mouth, where it is torn to pieces by the beak-like jaws and swallowed.

Octopus tuberculatus. Notice the short, rounded body and long arms provided with suckers. (Woodward.)

Like many other mollusks, the *Octopus* is esteemed by several savage tribes, as well as by some civilized people, as a valuable article of food. By the native of the Pacific coast the Octopus is caught by a very ingenious method. Providing himself with a spear twelve or fourteen feet long, which has four or five barbed pieces of hard wood some fourteen inches long attached to one end, the Indian paddles his canoe to the feeding-ground of the mollusk. One is soon found in ten or twelve feet of water, and the Indian carefully lowers his spear until within a few inches of the center of the animal, when he quickly plunges it into the soft mass. Instantly the water is in commotion, the eight long arms writhing about in an endeavor to reach the boat. The Indian knows that should this happen, his chances of life would be slim indeed. But he is prepared for the onset, and carefully lifting up the *Octopus* with his barbed spear until it is above the surface of the water,

he plunges a long, sharp spear, with which he is provided, into each arm where it joins the body. At each plunge of the spear, which paralyzes the nerve, an arm becomes helpless, and in a short time the animal, which but a few moments before had the power of a score of men, lies in the canoe, a shapeless and helpless mass. That the *Octopus* is a delicacy Professor Parker attested from experience, for during a visit to Yucatan, this mollusk was served to him as a meat dish, and proved to be very palatable, the flesh being firm and tender, and much resembling chicken. The portion eaten by him was the head, with a part of the arms attached.

One of the most interesting characteristics of the *Octopus* and allied *Cephalopods* is their power to change color when danger is near. These changes are caused, as has been noted before, by little pigment cells just beneath the skin, which expand and contract. Thus, if a person is looking at an *Octopus* in captivity, and the animal is so placed that it cannot escape, the observer will be astonished to see the body of the animal assume a deep pinkish color, which in turn is succeeded by blue and then by green, finally returning to pink. The body is covered with these little pigment cells, the different colors — pink, blue, and green — being so evenly distributed over the surface that when each cell is expanded the whole body assumes that tint.

The squid. Loligo pealii. (Tryon.)

The *Cephalopods* are broadly divided into two large divisions: in one, called *Dibranchiata*, the animal breathes by a single pair of gills, and in the other, called *Tetrabranchiata*, the animal breathes by two pairs of gills. The *Nautilus* is an example of this latter division. The first division is separated into two groups: the first, having no internal shell and eight arms, hence called *Octopoda;* and the second, with an internal shell, or pen, and ten arms, and called *Decapoda.* In this group, eight of the arms are short, like those in the *Octopus*, and two are very long, and are retractile within pouches. The ends of these tentacular arms are expanded to form club-like organs which are covered with suckers on the inside.

The squids, which are so common on the Atlantic coast of the United States, are good examples of the ten-armed *Cephalopods.* They are very numerous in numbers, and form a large part of the food of such fishes as the bluefish, black bass, and striped bass, and the young are frequently found in the stomach of jelly-fishes. They form the principal

food of the albatross, the petrels, and the dolphins, and they also furnish a large part of the food of some whales, as they are found in vast shoals and become ready victims of the huge monsters.

An ingenious method used by the fishermen of the New England coast for capturing a species of the smaller squids, *Ommastrephes illecebrosa*, is as follows: the squid has the habit of swimming in an opposite direction to a light, as that of the full moon; so the fishermen go out to sea in boats, light a large torch in each boat, and slowly row toward the shore, driving the squids, which of course swim backward in an opposite direction from the light, upon the beach, where they are gathered by thousands. Another method of capture is by jigging; the jig is made of a piece of lead some two inches in length, which is armed with a circle of sharp, unbarbed wires, pointing upwards and curving outwards. The process of jigging is accomplished as follows: the jig is attached to twelve or fifteen feet of stout line, which is lowered from the side of a small boat into water about ten feet deep. When near the bottom, it is kept moving up and down until a squid is felt upon it, when it is suddenly drawn to the surface with the squid attached. A somewhat similar method is employed by the natives of the Polynesian Islands to catch cuttlefish, the jigger being a piece of cowry shell fastened to a piece of wood which in turn is attached to a line. The captured squids are used as bait, and a single fishing-smack has been known to use as many as eighty thousand in a single season.

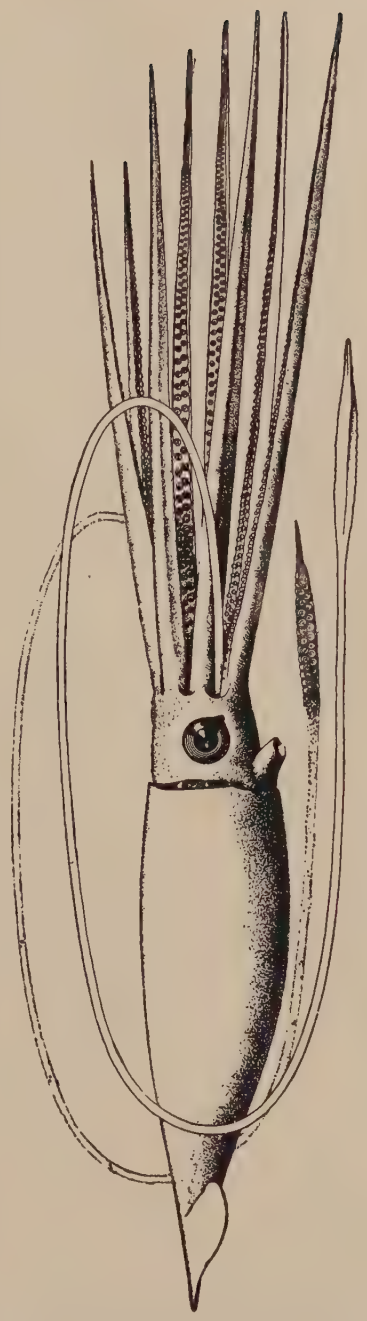
The squids are called "sea arrows," or "flying squids," by the fishermen, on account of the swiftness with which they dart through the water. They are very numerous, and are found in all seas. They feed on young fishes, such as mackerel, and are very adept at catching them, rapidly darting out and seizing the fish, which is instantly killed by a bite on the back of the neck.

In Norway and Sweden, there is a legend of a sea monster, called the Kraken. Enormous squids have been discovered during the last thirty years, and this legend probably had its origin on account of some great mollusk seen in early times. The Kraken was described as being of such size that it could wind its arms about the masts of a large ship and so overturn and sink it. These accounts were, of course, purely imaginary. Many of these large *Cephalopods* are found off the coast of Norway, Scotland, and Ireland, and not a few have been seen along the coasts of Nova Scotia and New England. In the larger of these animals, the body is eight or ten feet long, the short arms eight feet, and the tentacular arms thirty feet in length, making altogether, when stretched out, an animal about forty feet in length.

The giant squids are greatly prized as bait, and frequently a royal battle will take place between one of these gigantic creatures and a boat's crew. Sad, indeed, is the fate of the crew if the squid once obtains a firm hold of the boat. Great care is taken, however, to guard against such a result, and the animal is gradually deprived of its strength by making a sudden dash, cutting off an arm, and as quickly retreating. These large squids are not as common as are the smaller ones, and they are rarely captured.

The following accounts, taken from Tryon's Structural and Systematic Conchology, give an excellent idea of the size and appearance of these huge mollusks, and also the difficulties in capturing them:

"On the 30th of November, 1860, the French steamer Alecton, commanded by Lieutenant Bouyer, encountered, between Madeira and Teneriffe, an enormous Poulpe, which was swimming on the surface of the water. The animal measured fifteen to eighteen feet in length, without counting the formidable arms, covered with cups, which crowned its head. Its color was brick-red; its eyes had a prodigious development and frightful fixity. Its mouth, like the beak of a parrot, could be opened to the extent of eighteen inches. Its body, fusiform, but much swelled toward the center, presented an enormous mass, the weight of which has been estimated at more than four thousand four hundred pounds. Its fins, situated at the posterior extremity, were rounded in two fleshy lobes, and were of very large size. The commander of the vessel, on perceiving it, halted upon his course, and made preparations for captur-



Architeuthis princeps, a giant squid. One thirty-fifth natural size. (Sketch of model prepared at Yale College and published in Ward's Catalogue of Mollusca.) Models of this mollusk may be seen at Yale University, Hartford, Conn.; Harvard College, Cambridge, Mass.; and the Field Columbian Museum, Chicago, Ill.

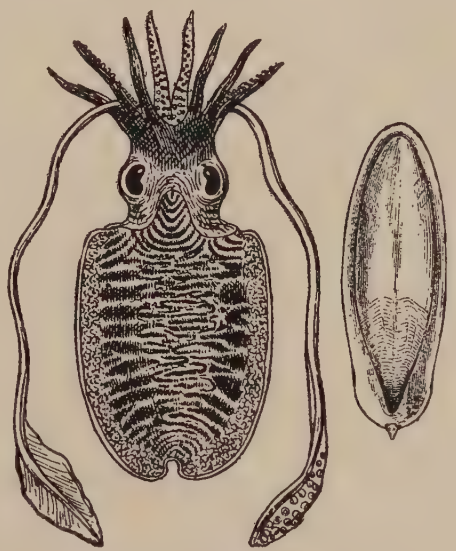
ing the monster. Guns were charged and harpoons hastily prepared; but at the first discharge of the former, the animal dived under the ship and immediately appeared on the other side. Attacked again with harpoons, it disappeared two or three times, and each time that it reascended to the surface, its long arms writhed. The ship followed or arrested its course according to the movements of the animal. This chase lasted more than three hours. The commander of the Alecton was determined to capture this new kind of enemy; nevertheless, he did not dare to lower a boat, for a single arm of this cephalopod would suffice to overturn it. The harpoons which were launched at it penetrated the flabby flesh and came out without success; several balls traversed it also unsuccessfully. Nevertheless, it received one of them, which appeared to wound it badly, causing it to vomit a great quantity of frothy matter and blood mixed with viscid matter, which spread a strong odor of musk. It was at this instant that they succeeded in lassoing the animal, but the rope slid along the elastic body until arrested by the fins. Attempting to haul their prize aboard, they had already drawn the greater part of the animal from the water when its enormous weight caused the rope to penetrate the flesh and separate the posterior portion of the body, which was drawn on board, whilst the rest disappeared in the sea."

The capture of a large cephalopod off the coast of Ireland is thus related, although the account is slightly exaggerated:

"On Monday last, the crew of a curragh, consisting of three men, met with a strange adventure northwest of Boffin Island. Having shot their spillets (or long lines), in the morning, they observed to seaward a great floating mass, surrounded by gulls; they pulled out, believing it to be a wreck, but to their great astonishment found it to be a cuttle-fish of enormous proportions, and lying perfectly still, as if basking on the surface of the water. A knife was the only weapon on board. The cuttle is much prized as a bait for coarse fish, and the crew resolved to secure at least a portion of it. Considering the great size of the monster, and knowing the crushing and holding powers of the arms, open hostility could not be resorted to, and the fishermen shaped their tactics differently. Paddling up with caution, a single arm was suddenly seized and lopped off. The cuttle, hitherto at rest, became dangerously active now, and set out to sea at full speed in a cloud of spray, rushing through the water at a tremendous rate. The canoe immediately gave chase, and was up again with the enemy after three-quarters of a mile. Hanging on the rear of the fish, a single arm was attacked in turn, while it took all of the skill of the men to keep out of the deadly clutch

of the suckers. The battle thus continued for two hours, and while direct conflict was avoided, the animal was gradually being deprived of its offensive weapons. Five miles out on the open Atlantic, in their frail canvas craft, the boatmen still slashed away, holding on boldly by the stranger, and steadily cutting down his powers. By this time, the prize was partially subdued, and the curragh closed in fairly with the monster. Such as remained of the ten great arms slashed around through the air and water in most dangerous but unavailing fashion. The trunk of the fish lay alongside, fully as long as the canoe, while in its extremity, the mutilated animal emitted successive jets of fluid, which darkened the sea for fathoms around. The head at last was severed from the body, which was unmanageable from its great weight, and sank like lead to the bottom of the sea. Of the portions of the mollusk taken ashore, two of the great arms are intact and measure eight feet each in length, and fifteen inches around the base. The two tentacles attain a length of thirty feet. The mandibles are about four inches across. The head, devoid of all appendages, weighed about six stone (about forty-eight pounds), and the eyes were about fifteen inches in diameter.

"It is evident, from the supine condition of this monster, that it was very sick or in a dying condition when attacked; otherwise it would have escaped capture readily by diving."



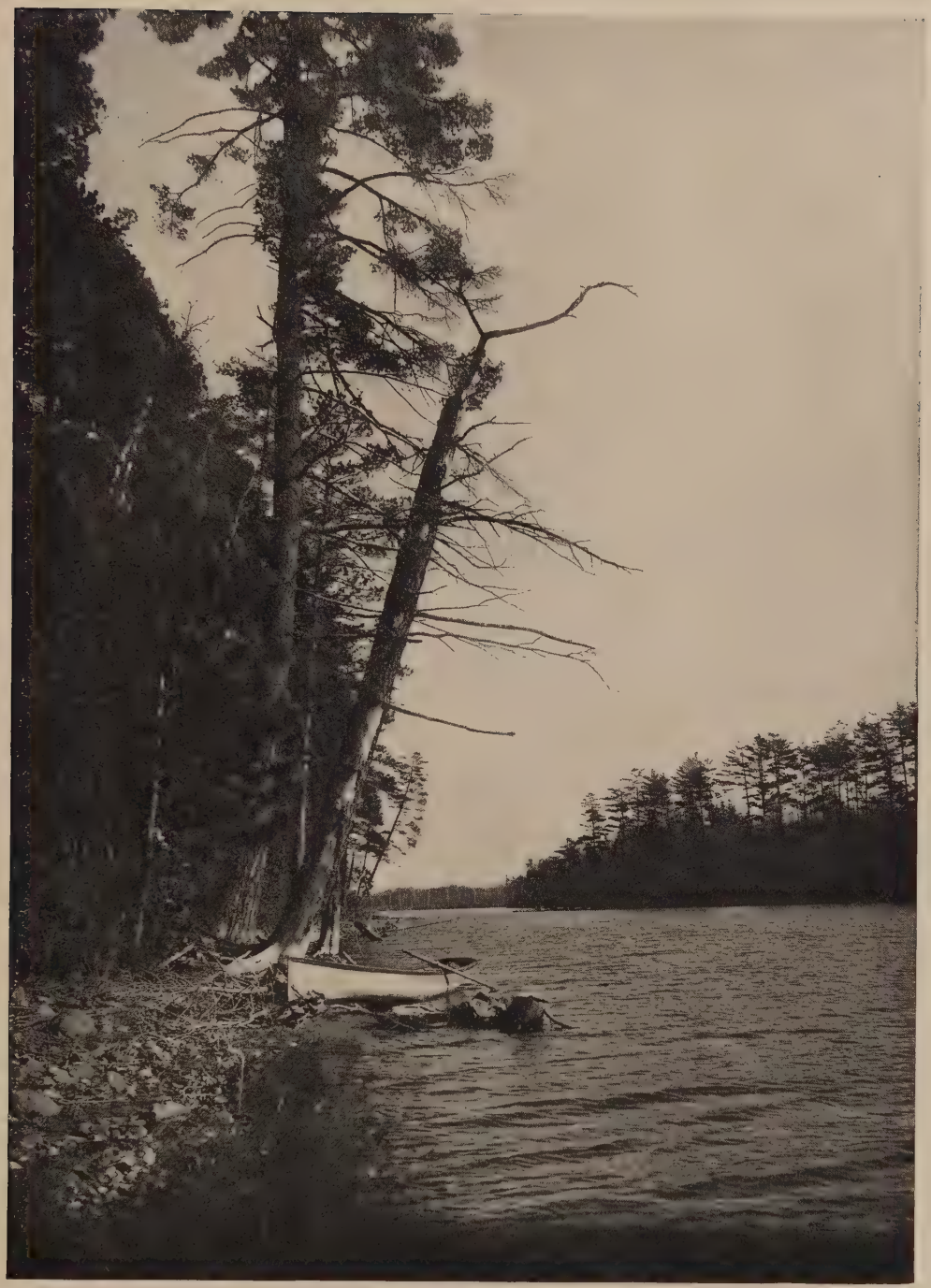
Cuttlefish, Sepia officinalis. The cuttle-bone is shown to the right of the figure. (Tryon.)

A familiar object to most canary-bird fanciers is the cuttle-bone placed in the cages of these birds for them to sharpen their beaks upon. The cuttle-bone is the internal support or shell of the cuttlefish, *Sepia officinalis*, and is homologous with the pen of the squid. The animal of *Sepia* is short and rounded, with a large head surrounded by a row of eight short and two very long tentacular arms, the latter ending in expanded clubs armed with powerful suckers. Like the *Octopus* and squid, the cuttlefish is capable of many changes of color by the changes in its pigment cells. They are found throughout the world, living near the shore, but the species found about the European coasts are the best known. The cuttlefish

is valued as an article of food in Italy, and is caught by the fishermen by many clever contrivances, among them being a dredge. The long arms of the *Sepia* are used to catch fish for food, as are those of the squids. At Rome, Italy, the pigment sepia is made from this animal, and at Liverpool, England, a dentifrice is manufactured from the chalky thickening of the cuttle-bone; it is said that twelve hundred pounds of cuttle-bone arrived at one time to be used for this purpose.

Mr. Tryon thus describes the wonderful changes of color in this animal: "But if the day is clear, the dorsal surface and arms are magnificently striped; the edges of the fins are black, and their superior face is ornamented with spots of the same color. The eye is fatigued in following the incessant variation of coloring caused by the constant movement of the pigment cells, and the metallic reflections of the head and arms are glorious beyond human skill to reproduce. The skin is usually smooth; but when the animal becomes irritated, it shows granulations, principally on the head and back. This is accompanied by a retraction of the arms, which appear both shorter and narrower; the extremes no longer touch, but curve slightly. At the same time the colors change; a uniform gray tint takes the place of the striped bands. The approach of death is equally announced by a change of colors, which grow dull."

Professor Parker further remarked that there were a large number of mollusks belonging to this class which are of great interest, but of which he had not time to speak. Many of the fossil *Cephalopods*, like the *Belemnites*, the *Ammonite*, the *Orthoceras*, and others, are worthy of mention. They are fashioned upon the same plan as those he had already described, and he assured us that their characteristics would be readily understood whenever we should see them or read about them.



WHERE THE FRESH-WATER MOLLUSKS LIVE

Photograph by F. M. Woodruff

THE CLASSIFICATION OF SHELLS

One evening, several weeks after our return from the coast, we called upon Professor Parker and found him busily engaged in study in his laboratory. We spent several hours very pleasantly in examining a large collection of shells, just purchased, and which came from all parts of the world.

In the course of our conversation, George asked why it was necessary to give the shells such long and hard scientific names. "Why wouldn't English names do as well?" he asked.

The Professor, who always willingly answered our questions, sat down and explained to us the reasons for the use of Latin and Greek names.

"In the first place," he said, "it is necessary to have the names in some language which is studied in all the countries of the world, and you are aware that Latin and Greek are the only languages which are universally used. If we were to use English names, the people in France, Germany, Russia, Japan, and other countries would not know their meaning; and so if the names were in any other language, the people of the other countries would not understand them. Then again, the use of the Latin and Greek languages enables the scientist to express in two or three words a meaning which would require a whole sentence in English, or some other modern language. Let us see if that is not true. We will take the name *Nerita subgranosa*, which means the 'nerite covered with a few grain-like pimples.' This is a Latin term. We may also use the Greek language, as in *Turbo chrysostoma*, which means the 'golden-mouthed turban shell.' And so this system may be used indefinitely.

"As you have doubtless learned in your studies, the Mollusca are classified systematically, each class, order, family, genus, and species being arranged in relation to other classes, orders, genera, and species. That is, all animals of one kind are placed in one group, as an order or family, while those differing from it are placed in other groups, and so on.

"For example, let us see how we would classify the common pond snail *Limnæa stagnalis*. We find that it belongs to the class *Gastropoda*,

or those mollusks which have a large foot on the lower surface; we next note that it can be placed in the order *Pulmonata*, which comprises those snails which breathe by a lung. Its next position is found in the suborder *Basommatophora*, which includes those snails having flattened and contractile tentacles, with eyes placed at their inner bases. These live for the most part in the water, but come to the surface for fresh air. Following out our analysis, we next find that it belongs to the family *Limnœidæ*, which includes the pond snails and orb shells. As it has a long spire it belongs to the genus *Limnæa*.

"If we tabulate this, we find that it appears as follows:

Class, Gastropoda.
Order, Pulmonata.
Suborder, Basommatophora.
Family, Limnæidæ.
Genus, Limnæa.
Species, stagnalis Linné.

"The specific name, *stagnalis*, signifies pond inhabiting, and indicates that the animal lives in ponds or lakes. In a number of mollusks, the specific name has a distinct meaning, and refers to some characteristic of the animal or shell; but in the majority of cases the name is simply arbitrary, and is used as a means of identification, just as are the names of persons, or the trade names of merchandise."

As the Professor ceased speaking, George inquired what the difference was between a genus, a species, and a variety. "That question," replied Professor Parker, "is a little difficult to answer in such a manner as to make it perfectly clear to you. A genus includes all of the animals having certain characteristics in common, as the genus *Limnæa*, which includes the pond snails with a long spire. The animals may also have certain features which distinguish them from other related animals, as the flat, triangular tentacles of *Limnæa*, which are different from the long, tapering tentacles of the orb snails, *Planorbis*. Species are distinguished by many minor features, the comparative length of the spire, the condition of the sutures separating the whorls, whether impressed, channeled, or plain, and the presence or absence of an umbilicus, or teeth within the aperture: all of these characteristics and many others serve to distinguish one species from another. A variety is very difficult to describe, as it is simply a minor modification of a species. To use a familiar illustration, the domestic cat, *Felis domestica*, is a species which comprises numerous varieties, as a black cat, a white cat, a black and white cat, or a tortoise-shelled

cat. These all belong to the species *domestica*, but are separated on account of their color into different varieties.

"The theory of evolution has led scientific men to recognize the fact that species and varieties do not exist in nature, life being a continuous whole, the simple animals developing into complex animals, and these again into still more complex forms of life, until the animals and plants have reached the myriad varieties we see about us to-day. Species are useful only, as I said before, as a means of identification, enabling us to compare the animals, or fauna, of one locality with another. But I am wandering from the question which you asked me. A species may be described as a group of animals which have certain characteristics not shared by any other living animals, while a variety is a group of animals closely related to the species, and connected with it by living gradations, but which have become slightly different through occupying a different part of the country, or by living on different kinds of food. A variety is sometimes called a geographic race. Man is one of the best examples of the difference between a species and a variety, and you are probably all familiar with the different races of men."

Howard, who had never studied scientific subjects before, asked Professor Parker what the word Linné meant, after *Limnæa stagnalis*. The Professor replied that this was the name of the great Swedish naturalist, Carl von Linnæus, or Linné, as it is frequently written. "The name of a person after the title of a species," he continued, "indicates the investigator who was the first to give the animal that Latin name, and by the presence of his name the student is able to refer to the original description of the animal or shell."

Professor Parker told us that it was always a good plan to make a collection that would contain the largest possible variety, illustrating all of the principal divisions of the Mollusca. This would, he said, be of great educational value to us, and would enable us to better understand the almost infinite diversity of form in this class of animals.

Many collectors, he added, made a generic collection, which embraced several representatives of all the genera. The Professor then impressed upon the quartette the importance and value of making a complete collection of the mollusks which lived in their immediate neighborhood.

In the course of the conversation George asked into how many classes the Mollusca are divided. The Professor replied by placing on his blackboard what he called an artificial key, which read as follows:

KEY TO CLASSES OF MOLLUSCA

A. Shell composed of two valves, or parts, generally placed side by side.
Clams, Oysters . . . . . *Pelecypoda.*
B. Shell composed of eight separate parts.
Coat of Mail shells . . . . . *Amphineura.*
C. Shell composed of one piece, generally in the form of a spiral.
Snails . . . . . *Gastropoda.*
D. Shell in the form of a hollow cylinder.
Tooth shells . . . . . *Scaphopoda.*
E. Head with eight or ten arms which are provided with numerous suckers; shell generally absent.
Squid, Nautilus, Devil-fish . . . . . *Cephalopoda.*

"Each class," continued the Professor, "is divided into numerous orders, and these in turn are divided into suborders, families, subfamilies, and genera, and all of these divisions may be arranged in keys, as you may see for yourself by consulting some of the books in my library. I would advise each of you to procure a good manual of Conchology and study it carefully."

Howard asked what was the most characteristic feature of shells, which was not shared by any other branch of the animal kingdom.

"The name Mollusca," answered Professor Parker, "is from the Latin word *Mollis*, meaning soft, and is given to this class of animals because their bodies are soft and fleshy. The most characteristic features of the Mollusca are the creeping disk, or foot, and in all but the *Pelecypoda*, the peculiar dental apparatus called the radula, or odontophore. In geological history the Mollusca extend back almost to the beginning of time, their remains being found in the early Cambrian rocks. There are at present about fifty thousand known living species, and the same number of fossil species."

As we were leaving to go to our several homes, the Professor handed each of us a slip of paper, containing a list of some books on Conchology, which he desired us to procure and study.

Several days after this visit to Professor Parker's house, a conchological club was formed, consisting of the quartette and several of their young friends, who had become interested in the subject. Professor Parker was by common consent elected an honorary member, and was unanimously made the first president. A plan was outlined for the winter, which embodied a thorough study of some of the most interesting groups of the Mollusca.

SOME BOOKS TO STUDY

At the first meeting of the new conchological club, the subject of what books to study was discussed. While the discussion was at its height, Professor Parker entered the room, and the chairman of the meeting, who happened to be Harry, referred the question to him. "I thought that you would discuss this subject this evening," said the Professor, "and I have brought with me a list of books and papers, together with some of the literature, which I shall present to the club to form a nucleus for its library.

"There are three valuable manuals, one of which, however, is in the French language. They are as follows:

"Structural and Systematic Conchology: an Introduction to the Study of the Mollusca. By George W. Tryon, Jr. Three volumes in one. Published by the Conchological Section of the Academy of Natural Sciences of Philadelphia. 1882–84.

"This work gives descriptions and figures of all of the orders, families, and genera of Mollusca, recent and fossil. It is indispensable to the student of the Mollusca, not only for its descriptions but for its abundant illustrations. Another, though older manual, is

"A Manual of the Mollusca; or, a Rudimentary Treatise of Recent and Fossil Shells. By Dr. S. P. Woodward. Published by various firms in London, England. 1868.

"The French manual of which I spoke is entitled, Manual de Conchyliologie; au Histoire Naturelle des Mollusques vivants et fossiles. By Dr. Paul Fischer. Published in Paris, France. 1880.

"Those who desire a knowledge of the shells of the west coast of America will find the following little volume of much value:

"West Coast Shells. A familiar description of the Marine, Fresh Water, and Land Mollusks of the United States found west of the Rocky Mountains. By Josiah Keep. Published by Bancroft Brothers and Company, San Francisco, Cal. 1887.

"No similar book has been written on the shells of the Atlantic coast; but a large amount of information and many excellent illustrations will be found in the following reports:

"A Preliminary Catalogue of the Shell-bearing Marine Mollusks and

Brachiopods of the Southeastern Coast of the United States. By William H. Dall. Published as Bulletin No. 37 of the United States National Museum. 1889.

"Report on the Invertebrata of Massachusetts. By A. A. Gould. Published by the Legislature of Massachusetts. 1841.

"Report on the Results of Dredging by the United States Coast Survey Steamer Blake. Report on the Mollusca. By William H. Dall. Published in the Bulletin of the Museum of Comparative Zoology, Harvard College:

"Part I. Pelecypoda, in Vol. XII. 1886.

"Part II. Gastropoda, in Vol. XVIII. 1889.

"Report upon the Invertebrate Animals of Vineyard Sound and the Adjacent Waters, with an Account of the Physical Characters of the Region. By A. E. Verrill. In the Annual Report of the United States Commissioner of Fish and Fisheries for the Year 1871–1872, pages 295 to 778.

"Two other interesting papers by the same author, one on deep sea mollusks and the other on the Cephalopoda, will be found in the same series of reports for 1879 and 1883.

"A very interesting account of marine life will be found in the Depths of the Sea. By C. Wyville Thompson. Published by Macmillan and Company, London. 1873.

"This volume gives an account of the deep sea dredging of the British steamers 'Porcupine' and 'Lightning' in the summers of 1868, 1869, and 1870.

"The following volumes give the most comprehensive account of deep sea work:

"Three Cruises of the United States Coast and Geodetic Survey Steamer Blake. By Alexander Agassiz. Published by Houghton, Mifflin, and Company, Boston. 1888.

"A very complete account of the methods and apparatus used in deep sea dredging will be found in the Report of the United States Fish Commission for the Year 1883, in a paper by Commander Z. L. Tanner, entitled

"Report on the Construction and Outfit of the United States Fish Commissioner's Steamer Albatross.

"Books on the land and fresh-water shells of the United States are out of print and hard to obtain; but the following may be consulted in the public library or museum:

"Land and Fresh-water Shells of North America. Parts I., II., and III. on the Pulmonata, and all but one family of the water-breathers.

By W. G. Binney and T. Bland. Published in Smithsonian Miscellaneous Collections, Nos. 194, 143, and 144. 1865 to 1869. Part IV., on the Strepomatidæ. By George W. Tryon, Jr., No. 253. 1873.

"Monograph of American Corbiculidæ, recent and fossil. By Temple Prime. Smithsonian Miscellaneous Publications, No. 145. 1865.

"This pamphlet contains descriptions and illustrations of the small bivales, Sphærium, Pisidium, etc.

"The best general work on American land shells is

"A Manual of American Land Shells. By W. G. Binney. Published as Bulletin No. 28 of the United States National Museum. 1885.

"The most elaborate and modern account of the land shells is found in

"A Guide to the Study of Helices. By Henry A. Pilsbry. Published by the Conchological Section of the Philadelphia Academy of Sciences. 1894.

"Many valuable papers by the same author will be found in the Proceedings of the Philadelphia Academy from 1890 to the present year.

"A volume containing many beautifully colored figures is

"Monograph of the Fresh-water Univalve Mollusca of the United States. By S. S. Haldeman. Philadelphia, 1840–44. Continuation by Geo. W. Tryon, Jr. Philadelphia. 1870.

"A volume devoted to the land and fresh-water shells of the Upper Mississippi Valley is

"The Mollusca of the Chicago Area. By Frank C. Baker. Published by the Chicago Academy of Sciences. 1902.

"This work contains many illustrations of the common species.

"The fresh-water clams, or Unios, have been carefully described and figured in

"Observations on the Genus Unio. By Isaac Lea. Thirteen volumes. 1834–1874. Philadelphia, Pennsylvania.

"These mollusks are catalogued and classified in a modern manner in

"A Synopsis of the Naiades; or, Pearly Fresh-water Mussels. By Charles T. Simpson. Published in the Proceedings of the United States National Museum, Volume XXII., pp. 501–1044. 1900.

"An excellent account of the pearl button industry will be found in Volume XVIII. of the United States Fish Commission; and the economic uses of mollusks are interestingly told in

"Etho-Conchology: A Study of Primitive Money. By Robert E. C. Stearns. Published in the Annual Report of the Smithsonian Institution. 1887. Part II., p. 297.

"This paper gives an excellent account of the use among primitive people, of shells, both as ornaments and as currency.

"Instructions for Collecting Mollusks, and Other Useful Hints for the Conchologist. By William H. Dall. Published in Bulletin No. 39, part G, of the United States National Museum. 1892.

"This paper gives full instructions for collecting and preserving the Mollusca. This, as well as other publications of the government, may be obtained by writing to the Secretary of the Smithsonian Institution, Washington, D. C.

"Those who desire a knowledge of the mollusks of Great Britain and Europe may consult the following volumes:

"British Conchology. By J. Gwyn Jeffreys. Five volumes. Published in London, England, from 1862–69.

"The Land and Fresh-water Mollusks Indigenous to, or Naturalized in, the British Isles. By Augustus Lovell Reeve. Published in London, in 1863.

"The Land and Fresh-water Shells of the British Isles. By Richard Rimmer. Published in Edinburgh, in 1880.

"A Monograph of the Land and Fresh-water Mollusca of the British Isles. By John W. Taylor. 1894.

"Histoire Naturelle des Mollusques de France. By Moquin-Tandon. Paris. 1855.

"A concise general account of the mollusks will be found in the article Mollusca, by E. Ray Lankester, in the Encyclopædia Britannica. Other general accounts will be found in the Zoologies of Parker, Zeitel, and Packard; the Standard Natural History; the Cambridge Natural History; and other general works of this character.

"Several valuable and costly monographs have been published, illustrated by many colored figures. Several of these may be consulted in the large libraries.

"Conchologia Iconica. By A. L. Reeve. Twenty volumes, 4to. London, 1843 to 1878. 2,600 colored plates.

"Thesaurus Conchyliorum; or, Figures and Descriptions of Recent Shells. By G. B. Sowerby. London, 1847. Over forty parts in 8vo.

"Systematischen Conchylien Cabinet von Martini und Chemnitz. A German work, of which over 325 parts have been published, containing over 1,800 colored plates. 4to.

"Those who desire a publication, in which all the known species of mollusks are described and figured, may consult the

"Manual of Conchology, Structural and Systematic, with illustrations of the Species. By George W. Tryon, Jr. Continuation by Henry

A. Pilsbry. Published by the Conchological Section of the Academy of Natural Sciences of Philadelphia. 1882.

"This work is issued in four series, of which the first, on the Marine Snails, has been completed; and the second series, on the Land Shells, is now in progress.

"There is one journal published in America, and several in Europe, which are devoted to the interests of conchologists. These are:

"The Nautilus: a monthly devoted to the interests of conchologists. Published by H. A. Pilsbry and C. W. Johnson. Philadelphia, Pennsylvania. 1889–.

"The Journal of Conchology. London, England. 1874–.

"Annales et Bulletin de la Société Malacologique de Belgique. Brusselles. 1863–.

"Journal de Conchyliologie. Paris. 1850–.

"These publications," continued Professor Parker, "are but a few of the many books and papers on this subject; but with the aid of these I have mentioned, you may identify and classify the majority of mollusks. There are thousands of papers scattered through the journals and transactions of domestic and foreign societies, many of which are of great value, but are too technical for your use at present. I would strongly advise each of you to make a card catalogue of all the papers relating to the Mollusca which you can find. It will be of great assistance if you will arrange the cards geographically as well as by authors. That is, all papers relating to the marine mollusks of California may be catalogued together, and all of those referring to the land shells of the United States. Experience will teach you many devices by which you will be able to systematize this subject."

GLOSSARY OF TECHNICAL TERMS

Several weeks after the first meeting of our club, we held another meeting, at which the subject of the terms or names used in study and description of the Mollusca, formed the subject of discussion. Professor Parker was present to assist the club in its debates.

"These technical terms," said the Professor, "are necessary in order that we may have a uniform means of describing the animals and shells. They are not difficult to understand when we appreciate their application to the animals. As your card, notifying me of this meeting, announced the subject for discussion to be the terms used in the study of the Mollusca, I thought a list or glossary of the majority of these terms might be of value to you, and form a kind of dictionary; and I have accordingly made several type-written copies of such a list." With these words, the Professor handed each of us a neat package of foolscap paper, containing the following glossary:

Aberrant. Deviating from a given type.
Abrasion. Wearing away.
Abyssal. The deepest part of the ocean.
Acephalous. Headless.
Acetabula. The suckers on the arms of squids and devil fishes.
Acinose. Full of small bulgings; resembling the kernel in a nut.
Aculeate. Very sharply pointed, as the teeth on the radula of some snails.
Acute. Sharp or pointed, as the spire of a shell or the lip of a shell.
Acuminate. Long and tapering, as the spire of some shells.
Admedian. Next to the central object, as the lateral teeth on the lingual membrane.
Afferent. To bring in; when relating to a vessel or duct, indicating that it brings in its contents.
Alate. Wing-like; as the dorsal part of some Unios.
Albinism. Changing from a darker to a lighter color.
Amœboid. Shaped like an Amœbia, a small animalcule.
Amorphous. Without distinct form.
Amphibious. Inhabiting both land and water.
Amphidetic. With the ligament on both sides of the umbones.
Ampullaceous. In the form of a flask.

Analogue. A likeness between two objects when otherwise they are totally different, as the wing of a bird and the wing of a butterfly.

Anastomosing. Coming together.

Androgynous. Combining both sexes in the same individual.

Annular. Made up of rings.

Anterior. The front or fore end.

Approximate. Near together, as the umbones of some Unios.

Aquatic. Inhabiting the water.

Arborescent. Branching like a tree.

Arched. Bowed or bent in a curve.

Archibenthal. The marine region lying between the deep sea (abyssal) and the shallow margin of the land (littoral).

Articulated. Jointed.

Arcti-spiral. Tightly coiled, as some spiral shells.

Arcuated. Bent in a bow or arched, as the ventral edge of some bivalves.

Asphyxiating. Causing suspended animation; apparent death.

Assimilation. Act of converting one substance into another, as the changing of food-stuffs into living bodies.

Asymmetrical. Not symmetrical.

Atrophied. Wasted away.

Attenuate. Long and slender, as in some shells.

Auditory. Connected with the hearing.

Auricled. Eared, or with ear-like appendages.

Basal. The bottom or lower part.

Benthal. The deepest part of the sea (the same meaning as abyssal).

Biangulate. With two angles.

Bicuspid or bicuspidate. Having two cusps.

Bifid. Having two arms or prongs.

Bifurcated. Having two branches.

Bilateral. With two sides.

Bilobed. With two lobes.

Bisexual. Having two sexes.

Bivalve. A mollusk with two valves or shells, as the Unio.

Branchial. Referring to the lower or ventral siphons in Pelecypods.

Bulbous. Swollen.

Byssiferous. Attached to a byssus, as in some Unios.

Caducous. Falling off or shedding, as of hair.

Calcareous. Composed of carbonate of lime.

Callosity. A hardened and raised bunch, as the callus on the columella of some shells.

Callus. A deposit of shelly matter.

Calyculate. Cup-like, as the umbo when separated from the rest of the shell by a distinct mark, as in Calyculina.

Campanulate. Formed like a bell.

Canaliculate. Resembling a canal, as the deep sutures in some shells.

Cancellated. Formed of cross-bars, as the longitudinal and spiral lines which cross in some shells.

Cardiac pouch. Containing the heart and placed near the umbones of the shell.

Carinate. Keeled.

Carnivorous. Feeding on animals.

Cartilaginous. Like cartilage.

Caudal. Tail-like, or with a tail-like appendage.

Cellular. Made up of cells.

Cerebral. Pertaining to the brain.

Channeled. Grooved or formed like a channel.

Chitinous. Formed of chitin, as the radulæ of snails.

Chromatophores. The pigment spots on the body of squids and devil fishes.

Ciliary. By means of cilia.

Ciliated. Having cilia.

Cilium (plural cilia). A lash; used to designate the hairs on the mantle, gills, etc.

Cirrated. Having movable hairs, as the siphons of Unio.

Clavate. Club-shaped.

Cloacal. Referring to the upper or dorsal siphon in Pelecypods.

Coarctate. Pressed together, narrowed.

Compressed. Flattened out, or pressed together, as some bivalves.

Concave. Excavated, hollowed out.

Concentric. From the same center, as the lines of growth on Sphærium, which are parallel with the umbo.

Confluent. To run together, or into something else, as the muscle scars of some Unios.

Congener. Belonging to the same group.

Conic. Shaped like a cone.

Connective. A part connecting two other parts, as a muscle connecting two parts of the body, or a nerve connecting two ganglia.

Constricted. Narrowed.

Contractile. Capable of being contracted or drawn in, as the tentacle of a snail.

Convex. Bulged out, as the whorls of some snails.

Convoluted. Rolled together.

Cordate. Heart-shaped.

Corneous. Horn-like, as the opercula of some mollusks.

Corrugated. Roughened by wrinkles, as the shells of some Unios.

Costate. Having rib-like ridges.

Crenulate. Wrinkled on the edges.

Crescentic. Like a crescent.

Cylindrical. Like a cylinder.

Deciduous. Falling off; applied to the parts of a shell which are not permanent, as the apex in some snails.

Decorticated. Peeled or stripped off, as the epidermis in some shells.

Decollated. Cut off, as the apex in some shells.

Decussated. With spiral and longitudinal lines intersecting, as the sculpture of some shells.

Deflexed. Bent downward, as the last whorl in some snails.

Dentate. With points or nodules resembling teeth, as the aperture of some snails.

Denticulate. Finely dentate.

Depressed. Flattened. As the spire in some snails.

Dextral. Right-handed.

Digitiform. Finger-like.

Dilated. Expanded in all directions, as the aperture of a shell.

Dimorphism. With two forms or conditions.

Dimyarian. Having two distinct adductor muscle impressions or scars, as in Unio.

Dicœcious. Having the sexes in two individuals, one male and one female.

Distral. The farthest part from an object.

Discoidal. Shaped like a flat disk.

Diverging. Separating from each other, as the cardinal teeth in some Unios.

Diverticulum. A pouch or hole, as the pouch containing the radula, or that containing the dart in helices.

Dormant. In a state of torpor or sleep.

Dorsal. The back. In bivalves the hinge portion, and in univalves the opposite to the aperture.

Ectocone. The outer cusp on the teeth of the radula.

Edentulous. Without teeth or folds, as the hinge plate in some Unios, and the aperture in some gastropods.

Efferent. Carrying out.

Elliptical. With an oval form.

Elongated. Drawn out, as the spire of a shell.

Emarginate. Bluntly notched.

Encysted. Inclosed in a cyst.

Entocone. The inner cusp on the teeth of the radula.

Entire. With even, unbroken edges, as the aperture of some shells.

Epithelium. All tissues bounding a free surface.

Equidistant. Equally spaced, as the spiral lines on some snail shells.

Equilateral. Equal-sided, as in Unio or Sphærium when the umbones are placed in the center.

Equilibrating. Balancing equally.

Equivalve. With both valves of the same size and shape.

Eroded. Worn away, as the epidermis on some shells.

Erosive. Capable of erosion.

Escutcheon. The region behind the umbones in opisthodetic pelecypods.

Excavated. Hollowed out, as the columella of some snails.

Excoriated. Worn away, or rubbed off.

Excurrent. Referring to the siphon which carries out the waste matter of the body.

Exoskeleton. The outer skeleton; all shells are exoskeletons.
Exotic. Foreign.
Exserted. Brought out.
Expanded. Spread out, as the lip of some shells.
Falcate. Scythe-shaped.
Fasciculus. A little bundle.
Ferruginous. Of the color of iron.
Filament. A slender, thread-like object.
Filiform. Thread-like.
Fissure. A cleft or cut.
Flagellate. Animals with a flagellum or lash.
Flavescent. Yellowish.
Flexuous. Formed in a series of curves or turnings, as the columella in some shells.
Flocculent. Clinging together in bunches.
Fluviatile. Living in running streams.
Foliaceous. Leaf-like.
Fuscous. Dark brown in color.
Fusiform. Thick in the middle and tapering at each end.
Gaping. Opening or spreading, as the valves of some Pelecypods.
Gelatinous. Like jelly, as the eggs of some mollusks.
Gibbous. Very much rounded, as the whorls in some snails.
Glandular. Like a gland.
Globose. Rounded.
Granulated. Covered with little grains.
Gravid. A female mollusk (as Unio) with ovaries distended with young.
Gregarious. Living in colonies.
Gular. Relating to the windpipe or palate. In mollusks, referring to the innermost part of the aperture.
Habitat. Locality of a species.
Hæmolymph. Molluscan blood.
Haliotoid. Ear-shaped.
Heliciform. In form like Helix.
Hemispherical. Half a sphere.
Herbivorous. Subsisting upon vegetable food.
Hermaphrodite. Having the sexes united in the same individual.
Hibernation. The act of hibernating or going to sleep for the winter months.
Hirsute. Covered with hairs, as some snails.
Hispid. Same as hirsute.
Homologous. Having the same position or value, as the wing of a bird and of a bat.
Hyaline. Glassy.
Imperforate. Not perforated or umbilicated.

Impressed. Marked by a furrow, as the impressed spiral lines on some univalve shells.

Inæquipartite. When one end of a shell is longer than the other, as the two ends in Pisidium.

Incrassate. Thickened.

Incurrent. The siphon in Unio which brings in the food-stuffs.

Incurved. Leaned or bent over, as the apex in some snails.

Indented. Notched.

Inequivalve. When one valve is larger than the other.

Inflated. Swollen, as some bivalve shells.

Inflected. Turned in, as the teeth of some snails.

Inhalent. Same as incurrent.

Inoperculate. Without an operculum.

Intercostate. Between the ribs or ridges.

Invaginate. One part bending into another, as the tentacles of some land snails.

Invertible. Capable of being inverted, or drawn in, as the eye-peduncles of a land snail.

Involute. Rolled inward.

Keeled. With a more or less sharp projection at the periphery.

Labial. Pertaining to the lips, as the labial-palpi in Unio.

Lamellated. Covered with scales.

Lamelliform. Having the form of scales.

Laminated. Consisting of plates or scales laid over each other.

Lanceolate. Gradually tapering to a point.

Lateral. Pertaining to the side.

Latticed. (See decussated.)

Lenticular. Having the shape of a double convex lens, as some bivalves.

Lithodesma. An accessory shell plate near the umbones, in those shells having a "cartilage" or resilium, as in Mactra.

Littoral. The region bordering the shore.

Lobulate. Composed of lobes.

Longitudinal. The length of a shell.

Lunate. Shaped like a half moon, as the aperture in some shells.

Maculated. Spotted.

Malleated. Appearing as though hammered.

Manducatory. Relating to the apparatus for masticating food. In snails, the jaws and radula.

Maritime. Inhabiting the seashore.

Marsupium. A part of an animal used as a pouch to contain the young, as the gills of Unio.

Median. Middle, as the middle tooth on the radula.

Mesocene. The middle cusp on the teeth of the radula.

Monœcius. Having the sexes united in the same individual.

Multifid. Made up of many lobes or projections, as the cusps on some radulæ.

Multispiral. Consisting of many whorls, as some fresh-water snails.

Nacreous. Pearly or iridescent, as the interior of some Unios.

Nave. The interior coating of Pisidium and Sphærium.

Nepionic. The second stage of the embryonic shell, as the glochidium of Unio.

Nodulous. Provided with small knobs or projections, as the surface of some Unios.

Notched. Nicked or indented, as the anterior canal of some gastropods.

Nucleus. The first part or beginning, as the apex in a univalve and the umbo in bivalves.

Nucleated. Having a nucleus.

Obconic. In the form of a reversed cone.

Oblique. Slanting, as the aperture of some shells when not parallel to the longitudinal axis.

Oblong. Longer than high, as some Unios.

Obovate. Reversed ovate, as some shells when the diameter is greater near the upper than at the lower part.

Obtuse. Dull or blunt, as the apex of some univalves.

Olfactory. Pertaining to the smell.

Olivaceous. Colored like an olive.

Opisthodetic. With the ligament behind the umbones.

Orbicular. Like an orb or disk, as some Sphæria.

Organism. An organized being, or living object made up of organs.

Ovate. Egg-shaped.

Ovately conic. Shaped like an egg, but with a somewhat conic apex, as some univalves.

Oviparous. Bringing forth young in an egg which is hatched after it is laid.

Ovisac. A pouch in which the eggs or embryos are contained.

Ovoviviparous. In this case the young are formed in an egg but are hatched inside the parent.

Papillose. Covered with many little bulgings or pimples.

Parallel. Having the same relative distance in all parts, as when the spiral lines in univalve shells are the same distance apart all the way around.

Parivincular. A ligament "which may be compared to a cylinder split on one side, attached by the several edges, one edge to each valve."

Patelliform. Shaped like a flattened out cone, as an Ancylus.

Patulous. Open and spreading, as the aperture in some univalves.

Paucispiral. Only slightly spiral, as some opercula.

Pearly. Having a substance like pearl, as the interior of Unio.

Pectinate. Like the teeth of a comb, as the gills of some mollusks.

Pedal. Pertaining to the foot.

Pedunculated. Supported on a stem or stalk, as the eyes of land snails.

Pelagic. Living in the open sea, away from the shore.

Pellucid. Transparent or clear, as the shells of some snails; e. g., Vitrea.

Penultimate. The whorl before the last in univalve shells.

Pericardium. The chamber containing the heart.
Periostracum. The epidermal covering of some shells, as Succinea.
Pervious. Very narrowly open, as the umbilicus in some snails.
Phytophagus. Vegetable-feeding.
Pilose. Covered with hairs.
Pinnate. Branched like a feather, as the gills of some mollusks.
Plaited. Folded.
Planorboid. Flat and orb-like, as some snails.
Pleuræ. Relating to the side of a body.
Plexus. A network of vessels, as the form of the lungs in snails.
Plicated. Made up of folds.
Plumose. Resembling plumes.
Polygonal. Having many angles.
Polymorphous. With many forms.
Porcellanous. Like Porcelain.
Post-basal. Beyond or near the base, as the posterio-ventral part of Lampsilis.
Prismatic. Like a prism.
Prodissoconch. The embryonic shell.
Prosodetic. A term applied to the area in opisthodetic ligaments, lying in front of the umbones and forming the lunule.
Protoconch. The embryonic shell.
Protract. To push out.
Protractor pedis. The foot protractor muscle.
Protrusile. Capable of being pushed out.
Proximal. The nearest end of an object.
Pseudocardinals. False cardinal teeth.
Pseudolaterals. False lateral teeth.
Pulsation. A throb, as the throbbing of the heart.
Pupiform. Like a pupa; one of the stages in the development of an insect.
Pustulate. Covered with pustules, or little pimples.
Pustulose. Same as above.
Pyramidal. Having the form of a pyramid.
Pyriform. Shaped like a pear.
Quadrangular. Having four corners, as some Unios.
Radiated. Extending from a common center, as the rays on some Unios.
Reflected. Bent backward, as the lip in some snails, or the cusps in the lingual membrane.
Reflexed. Same as above.
Renal. Relating to the kidneys.
Reticulated. Resembling a network, as when the longitudinal and spiral lines cross in a snail.
Retractile. Capable of being drawn in, as the eye peduncles in land snails.
Retractor pedis. Foot retractor muscle.
Reversed. Turned the contrary way.

Revolving lines. Spiral lines on a snail shell which run parallel with the sutures.

Rhombic. Having four sides, the angles being oblique.

Rhomboid. Four-sided, but two of the sides being longer than the others.

Rimate. Provided with a very small hole or crack, as some snails in which the umbilicus is very narrowly open.

Roundly lunate. Rounder than lunate (which see).

Rostriform. In the form of a rostrum.

Rudimentary. Not fully formed; imperfect.

Rugose. Rough or wrinkled, as parts of some shells.

Sacculated. Somewhat like a sac, or composed of sac-like parts.

Scalar or scalariform. Resembling a ladder.

Schizodont. With few teeth, consisting of one or two cardinals or laterals, as in Unio.

Scutellum. The projecting or pinched parts in front of the umbones in Pisidium.

Scutum. The pinched parts behind the ligament in Pisidium.

Secreted. Produced or deposited from the blood or glands, as the shell material in mollusks.

Semicircular. Half round or circular, as the aperture in some snails.

Semidentate. Half toothed, as the parietal wall in some land snails.

Semielliptic. Half elliptical.

Semiglobose. Half, or not quite globose.

Semilunate. Half lunate.

Semioval. Half, or not quite oval.

Serrated. Notched, like the teeth on a saw.

Serriform. In the form of series.

Sessile. Attached without a stem, as the eyes in some water snails.

Shouldered. Ridged, as the whorls in some snails.

Sigmoid. Shaped like the letter S.

Siliceous. Made up of silex.

Sinistral. Having the aperture on the left side.

Sinuous. Curved in and out, as the edge of some bivalves and the lips of some snails.

Spatulate. In the form of a spatula, a flat-bladed instrument used by druggists in pulverizing drugs.

Spherical. Shaped like a sphere.

Spiral. Wound about a central cavity, as the whorls of snails.

Striated. Marked by lines or striæ.

Subangulated. Moderately angled.

Subcarinated. Moderately carinated.

Subcentral. Not quite in the center

Subcircular. Not quite circular.

Subconical. Moderately conical.

Subcylindrical. Moderately cylindrical.

Subequal. Not quite equal.

Subexcavated. A little excavated.
Subfusiform. Moderately fusiform.
Subglobose. Moderately globose.
Subglobular. Moderately globular.
Subhyaline. Moderately glassy.
Subimperforate. Not much perforated.
Suboblong. Moderately oblong.
Subobsolete. Almost disappearing.
Subovate. Nearly ovate.
Subparallel. Almost parallel.
Subperforated. Almost perforated.
Subquadrate. Almost four-sided.
Subreflected. Moderately turned back.
Subrotund. Moderately round.
Subspiral. Moderately spiral.
Subtrianguiate. Moderately or almost triangular.
Subtrigonal. Moderately three-angled.
Subtruncate. Moderately cut off.
Subumbilicated. Moderately umbilicated.
Sulcated. Grooved.
Sulcus. A longitudinal furrow.
Superanal. Above the anus.
Supra-peripheral. Above the periphery.
Symmetrical. Alike on both sides or uniform in all parts.
Symphynote. Having the posterio-dorsal portion of the shell flattened and produced, as in Symphynota complanata.
Terrestrial. Living on the land.
Testaceous. Composed of shelly matter.
Torsion. A twisting around.
Tortuous. Twisted or winding.
Torpid. Half unconscious or asleep, as a snail during hibernation.
Translucent. Not quite transparent; light is seen through the thin edges of the object.
Transparent. Objects may be seen through the substance.
Transverse. Referring to the form of a shell when it is wider than high.
Tricuspidate. Having three cusps.
Trifid. Having three branches.
Trigonal. Having three angles.
Trilobate. Having three lobes.
Tripartite. Divided into three parts, as the foot of some snails.
Truncate. Having the end cut off squarely, as some Unios.
Tuberculate. Covered with tubercles or rounded knobs.
Tumid. Swollen.
Turbinate. Having the form of a top.

Turriculated. Having the form of a tower.
Turreted. Having the form of a tower.
Umbilicated. Having an opening in the base of the shell.
Undulated. Having undulations or waves, as the surface of some Unios.
Univalve. Having the shell composed of a single piece, as a snail.
Varicose. Swollen or enlarged.
Vascular. Containing or made up of blood-vessels.
Vermiform. Formed like a worm.
Ventral. The lower border or side.
Ventricose. Swollen or inflated on the ventral side.
Vibratile. Moving from side to side.
Viscous. Sticky.
Vitreous. Resembling glass, as some snails.
Viviparous. Bringing forth the young alive as in the genera Vivipara and Campeloma.
♂ Male. The astronomical sign for the planet Mars.
♀ Female. The astronomical sign for the planet Venus.

CONCLUSION

The first year of the Conchological Club's history was one of great success. Under the guidance of Professor Parker, meetings were held every two weeks, at which, papers were read by the members and specimens were brought for identification. At several of the meetings, the Professor gave popular lectures on familiar branches of the subject. These were not only attended by the members of the club, but by many other people who were interested in the study of Nature. For these lectures, a large hall was secured in one of the University buildings, and so great was the interest that the room was frequently crowded.

At the end of the year, the secretary's annual report (Howard being the secretary) gave the membership as twenty-five, showing that the club had increased its membership sixfold during this period. The library was also growing rapidly, and it was found, when the reports of several of the members were read, that two members, Howard and Harry, had accumulated over twelve hundred species of mollusks. "This is very encouraging," said Professor Parker, when, as the first president of the club, he rose to make a few remarks; "and I am sure your enthusiasm will not lag, and that you will continue to make a study of the subject rather than to make a mere collection for the sake of possessing a large variety of shells. I have thought that we could commence this year a small magazine of several pages, devoted to the interests of conchologists. This would help to stimulate interest in the subject, and be a means of exchanging notes with conchologists in other cities. If you will appoint a publication committee, I will be very happy to talk the matter over, and determine when we shall start the magazine, and of what size and character it shall be. I would suggest that for a title, such names as 'The Argonaut,' 'The Nautilus,' or 'The Conchologist' might be appropriate.

"In closing my remarks," continued Professor Parker, "I wish to say that it has given me much pleasure to be your president for the past year, and to be able to aid you in your studies. But above all, I have been gratified to note that the study of these lowly creatures has made you better and broader men. You have not only grown more observing, but have cultivated a willingness to receive the ideas and

thoughts which the contemplation of these wonderful bits of creation has suggested to your minds.

"In a new sense, has the great world become to you a storehouse of animate forms. Very many species of life have been revealed to you, with all their complex being, their wonderful adaptation to their environment, their endless and astonishing variety, and the marvelous stories of their life histories.

"You seem almost to have visited the 'secret places of the Most High,' and to have wrested the hidden things from their hiding-places. Never again can the earth appear to you commonplace and unattractive. Rather you will long for ages to penetrate farther into the mysteries of created things, of which as yet you seem only to have looked through an open door to the wealth of knowledge beyond.

"Allow me, as my parting word, to recall to your minds the guiding sentiment of the club, so wisely chosen:

> "'*The more things thou learnest to know and to enjoy, the more complete and full will be for thee the delight of living.*'"

INDEX

	PAGE
Abalone	96, 97, 111
Abyssal region	87
Acephala	6
Achatina	48
Achatinella	48
Achatinellidæ	48
Actinia	75
Æolis drummondi	43
Algæ, stony	87
Ammonite	132, 135, 142
Amnicola	23, 36
Amnicola limosa	16
Amnicola limosa, radula of	44
Amphibious snails	21
Amphibolidæ	23
Amphineura	95, 147
Ampullaria	21
Ampullaria depressa	21
Ampullaria, food of everglade kite	21
Ampullariidæ	20
Ancilla	119
Ancilla glabrata	119
Ancylus	14
Ancylus rivularis	14, 34
Ancylidæ	19
Angel wings	80
Animal, deep sea	88
operculum of	88
eyes of	88
organs of	88
temperature of water	88
Anemone, sea	75, 85
Anodonta	8, 9
Anomia	73
Anomia simplex	73
Aplustrum	105
Aplysia	105
Aplysia depilans	104
Aporrhais	102
Aquarium	34, 35, 36, 39
Arca pexata	68
Archibenthal region	87
Architeuthis princeps	139
Argonauta argo	135
Argonaut	135
Arion	52
Ark shells	77
Aristotle	75
Aspergillum	81
Aspergillum vaginiferum	81
Astartes	77
Auriculidæ	31
Basommatophora	145
Beads, shell	110
Belemnites	142
Benthal region	87
Bivalves	2, 6, 12, 69
Bladderwort	37
Books to study	148
Buccal sac	39, 40
Buccinum	110, 121, 122
Buccinum undatum	43
Buccinidæ	122
Buckie	121
Bugs, sea	95
Bugs, pill	92
Bulla	92, 104
Bulimulus	48
Bulimus	48, 51
Bulimus oblongus	47
Bulimus ovatus	47
Butterflies, sea	124
Butterfly	93
Byssus	8, 69
Bythinia tentaculata	22
Cæcum	16
Calliostoma annulatum	97
Calliostoma bairdii	88
Calliostoma zizyphinum	97
Calyculina	8
Calyculina transversa	9
Calyptræa	101
Cameo shells	116
Cameos	116
Campeloma	16, 20
Campeloma decisum	14, 15
Capulus	101
Cardiidæ	70
Cardium	70
Cardium, foot of	70
Cardium edule	70
Cardium isocardia	70

PAGE

Cardium magnum - - - 70
Cassis tuberosa - - - 116
Cat, domestic - - - - 145
Caterpillar - - - - 93
Cephalopoda - - - 132, 147
Cephalopods 132, 133, 134, 136, 137, 138, 142
Cephalopods, fossil - - - 142
Cerion - - - - - 48
Cerion chrysalis - - - 48
Cerithiidæ - - - - - 99
Cerithites - - - - - 92, 99
Cerithium - - - - - 91, 99
Chalcedony - - - - - 78
Chama - - - - - 78
Chama arcinella - - - 78
Chama macrophylla - - 78
Chama pellucida - - - 78
Chamidæ - - - - - 78
Chank - - - - - 120
Chitons - - - - 91, 92, 95
Chop suey - - - - 98
Chrysodomus - - - 122
Chrysodomus antiquus - - 122
Circinaria - - - - 37, 51
Circinaria concava, animal of - - 37
Clam - - - 2, 3, 4, 69, 78, 147
age of - - - - 3
brain of - - - - 6
chicken - - - - 78
ear of - - - - 6
digging for razor - - 79
enemies of - - - 67
feeding of fresh-water - - 34
female - - - - 8
fresh-water - - - 2, 5, 6, 34
giant - - - - - 70
hen - - - - 78
introduced on Pacific coast - 80
male - - - - 8
opened by muskrats - - 8
razor - - - - 67, 79
soft-shelled - - - 62, 79, 83
soft-shelled, anatomy of 63, 64, 65, 66
Washington - - - - 79
worm - - - - 85
Classes of Mollusca, key to - - 147
Classification - - - 144
Clausilia - - - - - 49
Clausilium - - - - 49
Club, conchological - - - 148
Cochlicopa lubrica - - - 31
Cochlostylas - - - - 47
Cockle - - - - 70
Cockle, edible - - - - 70
Collecting, lake - - - 2
localities, good - - - 17

PAGE

Collecting, localities, poor - - 17
outfit for land snails - - 26
tools for marine - - - 61
tools for fresh-water - - 1
Collections, accession catalogue for 58
card catalogue for - - - 58
cardboard trays for - - 58
labeling of - - - - 58
labels for - - - - 58
preservation of - - - 58
Columbella - - - - 92, 118
Conchological club - - - 148
Cone, bite of - - - 118
textile - - - - 118
Conidæ - - - - 117
Conus - - - - 107, 117, 119
marmoreus - - - 118
proteus - - - - 118
textile - - - - 118
Coral reefs - - - - 91
Coralline zone - - - 87
Cowry, arabic - - - - 109
deer - - - - 109
lynx - - - - - 109
money - - - - 108
map - - - - - 109
orange - - - - 109
panther - - - - 109
pustulose - - - - 109
rat - - - - - 109
rhinoceros - - - 109
serpent's head - - - 109
shell - - - - 106
thrush - - - - 109
tiger - - - - 109
Crab, clams as food for - - 79
fiddler - - - - 63
hermit - - - 92, 121
horse-foot - - - 91, 125
soft-shelled - - - - 125
Crabs - - - - 85
Crepidula - - - 91, 101
Cylindrella - - - - 17
Cymbium - - - - 120
Cypræa - - 106, 107, 109, 117, 119
animal of - - - - 107
annulus - - - - 108
arabica - - - - 109
argus - - - - 107
aurantia - - - - 109
caputserpentis - - - 109
cervus - - - - 109
decipiens - - - - 109
guttata - - - - 109
lynx - - - - 109
mappa - - - - 109

PAGE

Cypræa, mauritiana - - 108
moneta - - - - 108
mus - - - - 109
pantherina - - - - 109
princeps - - - - 109
pustulata - - - - 109
rhinoceros - - - 109
scottii - - - - 109
testudinaria - - - 107
tigris - - - - 107, 109
turdus - - - - 109
umbilicata - - - - 109
Cyrenas - - - - 78
Cytherea lupinaria - - - 69
Cuttle-bone - - - - 141
Cuttlefish - - - 129, 141

Decapoda - - - - 137
Decollated shells - - - 16
Deep sea animals - - - 88
animals, eyes of - - - 88
animals, operculum of - - 88
animals, organs of - - - 88
pressure of - - - 88
temperature of water of - - 88
Dentalium - - - - 94, 110
elephantinum - - - 94
entalis - - - - 105
Devil fish - - - - 147
Dibranchiata - - - 137
Distoma - - - - - 31
Distribution of mollusks by human agencies - - - 23
Dog whelks - - - - 120
Dolium - - - - - 15, 117
perdix - - - - 117
Donax - - - - 79
Doris - - - - - 91
tuberculata - - - 43
Dove shells - - - - 118
Dredge, description of - - 89
Dredging, difficulties of - - 89
method of - - - 89, 90
specimens obtained by - - 90
Drill - - - - 72, 83, 84, 85
anatomy of - - - 84, 86
boring of in clams - - 86, 87
Duckweed - - - - 37
Dye, purple, of Murex - - 113

Eburnea - - - - - 122
Eggs of snails, calcareous - - 47, 48
Ensis directus - - - - 67, 79
Epiphragm of helices - - 32, 33
Epiphragm of pond snail - - 18
Epiphragmophora fidelis - - 47

PAGE

Everglade kite, Ampullaria as food of - 21
Evolution, theory of - - 146

Fasciolaria - - - - 123
distans - - - - 123
gigantea - - - - 123
Felis domestica - - - 145
Female clam - - - - 8
Ferns - - - - 37
Fissurella - - - - 96
Fissurellidæ - - - - 96
Five fingers - - - - 85
Fluke worm - - - - 31
Fluminicola - - - - 23
Fulgur - - - 91, 110, 122, 131
canaliculatus - - 91, 131
eggs of - - - - 92
Fusidæ - - - - - 122
Fusus - - - - 122

Gari vespertina - - - - 71
Garden slug, shell plate of - 27
Gastrodonta ligera, animal of - - 37
Gastropod - - - 79, 85, 101
Gastropoda - - - 144, 145, 147
Genus, definition of - - 145
Glandina - - - 22, 37, 51
Glochidium - - - - 7, 8
Glossary - - - - - 153
Gyrineum - - - - 123

Hai-kwa - - - - - 110
Haliotis - - - 96, 97, 111
money - - - - 110
Harpa - - - - 104
rosea - - - - - 104
ventricosa - - - 104
Ha-wok - - - - - 111
Hawock - - - - 110, 111
Helices - - - - - 32, 46
Helix ghiesbreghti - - - 43
nemoralis - - - - 49
pomatia - - - - 43, 48, 49
Helmet shell, black - - - 116
sardonyx - - - - 116
Hibernation - - - - 33
Hipponyx - - - - 101
Hiqua - - - - - 110
Hyalæa trispinosa - - - 124
Hydractinia - - - - 92

Idol shells - - - - 21

Janthina - - - - 115
fragilis - - - - 115

Kelp, long-leaved - - - - 87

PAGE

Key to classes of Mollusca - - 147
Kol-kol - - - - 110, 111
Kop-kop - - - - - 110
Kraken - - - - 138

Lacuna - - - - - 100
Laminaria - - - - 87
Laminarian zone - - - 87
Leucochloridium americanum - 31
Ligament - - - - 2, 4
Liguus - - - - 48, 51
fasciatus - - - - 47
Lima - - - - - 74, 75
nest of - - - - 74
swimming of - - - 74, 75
squamosa - - - - 74
Limax - - - - 52
agrestis - - - - 27
campestris - - - 52
flavus - - - - 51
flavus, jaw - - - 43
maximus - - - - 52
Limidæ - - - - 74
Limnæa - - 13, 14, 18, 19, 31, 145
caperata - - - - 43
desidiosa - - - - 11
mighelsi - - - - 12
mighelsi, animal of - - - 35
reflexa, mouth of - - 45
stagnalis - - 11, 144, 145, 146
Limnæidæ - - - 18, 21, 145
Limnotrochus thomasi - - 22
Limpet - - - - 91, 95, 96
as food - - - - 96
bonnet - - - - 101
cup and saucer - - - 101
feeding of - - - 96
fresh-water - - - 34
keyhole - - - - 96
river - - - - 19
strength of - - - 96
Lines of growth - - - 3
Lingual ribbon - - - 39
Linnæus - - - - - 146
Liocardium elatum - - - 70
Lithodomus - - - - 77
Littoral region - - - 87
Littorina - - - 99, 100
angulifera - - - 100
littorea - - - - 86, 99
Littorinidæ - - - - 22
Liverfluke - - - - 31
Loligo pealii - - 127, 130, 137
Lucina, foot of - - - - 77
chrysostoma - - - 77
tigrina - - - - 77

PAGE

Lucinidæ - - - - 77
Lung breathers - - - 18

Mactra - - - - - 78, 79
Malleus vulgaris - - - 76
Marginella - - - - 119
Marsupia - - - - 7, 8
Melampus - - - - 93
Melania - - - - 20
Melaniidæ - - - - 20
Meleagrina margaritifera - - 76
Melo - - - - - 120
Melongena corona - - - 122
Microscope - - - - 40, 41
Miter, episcopal - - - 103
papal - - - - - 103
pontifical - - - 103
Mitra - - - - - 103
cardinalis - - - 103
episcopalis - - - - 103
papalis - - - - 103
pontificalis - - - - 103
Modiola - - - - 76, 77
plicatula - - - - 77, 93
Mollusca - - - - 69, 147
definition of - - - 145, 147
key to classes of - - - 145, 147
family of - - - 145, 147
genus of - - - - 145, 147
order of - - - 145, 147
species of - - - 145, 147
suborder of - - - 145, 147
variety of - - - 145
Mollusks, pelagic - - - 124
phosphorence of - - - 80
young - - - - 93
Money, black - - - 110
cowry - - - - 109
cowry, value of - - - 109
shell - - - - 109
tooth shell - - - 94

Monoceros - - - - 114
Moss - - - - - 37
Mother-of-pearl - - - - 76, 77
Murex - - - 107, 111, 114, 123
adustus - - - - 112
axicornis - - - - 112
bicolor - - - - 113
erinaceus - - - 114
pomum - - - - 112
radix - - - - 113
ramosus - - - - 112
tenuispina - - - 111
trunculus - - - 113
Murices - - - - 111, 112

PAGE

Muskrat opening clams - - 8
Mussels - - - - - 2
black - - - - - 63
byssus of - - - - 76
edible - - - - - 77
fishing for - - - 77
pearls of river - - - 72
river - - - - 72
Mutlog - - - - - 121
Mya - - - - - 79
arenaria - - - - 62
Mytilus edulis - - - 63, 77

Nassa - - - 91, 92, 120, 121
mutabilis - - - 121
obsoleta - - - 92, 120, 121
reticulata - - - 121
Natica - - - 91, 101, 102, 121
eggs of - - - - 92
Nautilus - - - 132, 133, 134, 147
anatomy of - - - 133
a living - - - - 133
fishing for - - - 133
pearly - - - - 132
pompilius - - - 132, 133
Nerita - - - - - 98
peloronta - - - 98
subgranosa - - - - 144
Neritina fluviatilis - - - 99
virginea - - - - 98
Neritinas - - - - 98
Nucula - - - - - 77
Nudibranchiata - - - 124

Octopoda - - - - 137
Octopus - - 133, 135, 136, 137, 141
fishing for - - - - 136
prey of - - - - 136
tuberculatus - - - 136
Odontophore - - - 39, 147
Oleacina - - - - - 51
Oliva - - - - - 119
volutella - - - - 119
Olivella biplicata - - - 111
shell money - - - - 110
Ommastrephes illecebrosa - 138
Omphalina fuliginosa - - - 33
Operculum, calcareous - - 86
horny - - - - 86
preservation of - - - 57
variation of - - - - 85, 86
Ormers - - - - 97
Orthalicus - - - - 51
Orthoceras - - - - 142
Ovula, canal of - - - - 84

PAGE

Ostrea talienwaniensis - - - 73
virginica - - - - 72
Oyster - - - 2, 69, 72, 73, 147
cock's comb - - - 73
culture - - - - 72
eggs of - - - - 73
enemies of - - - - 72
food of - - - - 72
hammer head - - - 76
organs of - - - - 72
size of - - - - 73
spiny - - - - 74
thorn - - - - - 74
tree - - - - 73
young of - - - - 73

Pachydesma crassatelloides - 111
Paludinella - - - - 23
Paper sailor - - - - 134
animal of - - - - 135
shell of - - - - 135
Parapholas californica - - - 80
Parietal wall of land snail - - 27
Patella - - - - - 95
longicosta - - - 95
Pearl images - - - - 76
Hope - - - - 76
oysters - - - - 75, 76
Pearls, artificial - - - 76
how formed - - - - 76
Pecten jacobæus - - - 74
maximus - - - - 74
Pectinidæ - - - - 73
Pelagic mollusks - - - 124
Pelecypoda - - - - 69, 147
Pelecypods - - - - 70
Pericardium - - - - 7
Peristome - - - 26, 27
Periwinkle - - 83, 91, 92, 99, 110
anatomy of - - - 86
radula of - - - - 99
Phasianellidæ - - - - 97
Pholas - - - - 80
dactylus - - - - 80
Phosphorescence of mollusks - 80
Physa - - - 13, 14, 19, 20, 36
gyrina - - - - 13
gyrina, animal of - - - 36
gyrina, egg mass of - - 36
Physas - - - - - 13, 17
Physidæ - - - - 19
Piddock - - - - - 80
boring of - - - - 80
california - - - - 80
Pill bug - - - - 92
Pinna, articles made from - - 75

PAGE

Pinna, guardian - - - 75
nobilis - - - - 75
Pinnidæ - - - - 75
Pinnotheres - - - - 75
Pisidium - - - - 78
Planorbis - - - 13, 19, 145
bicarinatus - - - 38
campanulatus - - - 38
corneus - - - - 19
parvus - - - - 19
trivolvis - - - - 38
truncatus - - - - 38
Pleurocera - - - - 15, 16
elevatum - - - - 15
Pleurotoma babylonia - - 118
Pleurotomidæ - - - - 118
Pliny - - - - - 76, 78
Polinices heros - - - - 92
Polygyra albolabris - - - 26, 47
palliata - - - - 25
pennsylvanica - - - 41
thyroides, jaw of - - - 43
tridentata, teeth of - - 41
Polyzoa - - - - - 87
Pomatiopsis - - - - 23
Potamides - - - - 99
Poulpe - - - - 139
Proboscis contractile - - - 15
retractile - - - 15
Protective coloration - - - 47
Psammobia, red-streaked - - 71
rubroradiata - - - 71
siphons of - - - 71
Psammobiidæ - - - 71
Pteria radiata - - - 76
Pteriidæ - - - - 75
Pterocera - - - - 102
Pteropoda - - - - 124
Pulmonata - - - - 46, 145
Pupa - - - - 29, 30, 43, 49
Pupidæ - - - - 49
Purpura - - - - 92, 113, 114
lapillus - - - - 92, 113
lapillus, eggs of - - - 92
Pyramidula alternata - - 32
solitaria - - - - 32
Pyrula papyratia - - - 117

Quahog - - - 68, 69, 73, 110

Radula - - - 39, 40, 41, 147
parts of - - - 41, 42
Radulæ, preparation of minute - 41
staining - - - - 44
Region, Abyssal - - - 87
Archibenthal - - - 87

PAGE

Region, Benthal - - - 87
Littoral - - - - 87
Rest periods - - - 3
Ricinula - - - - - 114
ricinus - - - - 114
Rissoa costata - - - - 93
Rostrum - - - - 15

Saxidomus aratus - - - 111
Scala - - - - - 92, 115
pretiosum - - - - 115
Scallop - - - - - 73, 74
dancing - - - - 73, 74
Scaphander - - - - 105
Scaphopoda - - - 94, 147
Scavenger, molluscan - - 121
Sea anemone - - - - 75, 85
arrows - - - - 137
bugs - - - - - 95
butterflies - - - 124
ear - - - - - 97
Seaweeds - - - - 85
Sepia - - - - 141, 142
officinalis - - - - 141
Serapis, temple of - - - 77
Shells, apple rock - - - 112
ark - - - - 68, 77
augur - - - - 102
basket - - - 91, 120, 121
bat - - - - 120
beads - - - - - 110
black basket - - - 92
bleeding tooth - - - 98
boat - - - - 120
boatman bubble - - - 105
bubble - - - - 92, 104
branched rock - - - 112
burnt rock - - - 112
carrier - - - - 101
castor oil - - - - 114
coat-of-mail - - - 92, 95, 147
date - - - - 77
decollated - - - - 16
dove - - - - 92, 118
ear - - - - - 97
embryonic - - - 7
fig - - - - - 117
file - - - - 74
frog - - - - - 123
Greek name of - - - 144
harp - - - - 103, 104
heart - - - - 70
helmet - - - 116, 117
horned rock - - - 112
horse-hoof - - - - 101
idol - - - - 21

PAGE

Shells, ivory - - - 122
jingle - - - - - 73
ladder - - - - 92, 115
Latin name of - - - 144
lightning - - - 122
maiden - - - - 119
melon - - - - 120
moon - - - 91, 92, 101
mussel - - - - 76
names of, why given - - 144
Neptune - - - - 122
nut - - - - - 77
olive - - - - 119
orb - - - - - 13, 19
pelican's foot - - - 102
pheasant - - - - 97, 98
purple - - - 92, 113, 114
rice - - - - - 119
rock - - - - 111
root rock - - - - 113
Saint James - - - 74
screw - - - - - 100
ship's flag bubble - - 105
slipper - - - 91, 101
spider - - - - 102
steeple - - - - 102
tooth - - - - 94
top - - - - 97, 98
trumpet - - - - 123
tun - - - - - 117
turban - - - - 97, 98
two-colored rock - - - 113
Venus - - - - 69
watering pot - - - 81
wedge - - - - 78
wing - - - - - 75
winkle - - - - 91
worm - - - - - 100
Shankh - - - - 120
Ship worm - - - - 80
Shore, muddy - - - 91
rocky - - - - - 91
sandy - - - - 91
Sigaretus - - - - 102
Siphonaria - - - - 23
Siphons, variation in - - - 67
Slug, garden - - - 27
sea - - - - 91, 124
shell plate of garden - - 27
Slugs, preservation of - - - 57
Snailery - - - - 34, 36, 39
Snails - - - - - 147
amphibious - - - 21
anatomy of land - - - 39, 40
anatomy of pond - - 12
apple - - - 15, 16, 17, 20, 21, 36

PAGE

Snails, banded - - - 123
bee hive - - - - 48
breathing of pond - - 13
carnivorous - - 49, 50, 51, 84, 121
carnivorous land - - 37
cleaning - - - - 55
crawling on surface of water - 35
desert - - - - 47
dextral - - - - 13, 14
edible - - - - 48, 49
eggs of land - - - 38
eggs of fresh water - - - 36
feeding of - - - 34, 37
forms of - - - - 85
fresh water - - - 18
geographical distribution of - 53
good locality for land - - 26
habitat of land - - - 46
injurious - - - - 52
introduced - - - 46, 51, 52
jaw of land - - - 37
length of life of - - - 52
localities for land - - 30
lung of pond - - - 13
mouth parts of - - - 45
orb - - - - - 35
parts of land - - - 26
parts of pond - - - 11
pond - - - 18, 21, 34, 35, 36
sinistral - - - 13, 14
sleep of - - - - 33
solitary - - - - 32
speed of land - - - 38
tadpole - - - - 36
teeth of - - - - 40, 41, 42
tools for cleaning - - 55, 56
tree - - - - 47
vegetable eating - - - 84
violet sea - - - - 115
violet sea, raft of - - - 115
white lipped - - - 47
white lipped, anatomy of - 27, 28, 29
white lipped, locomotion of - 28
white lipped, parts of animal of - 27
without external shell - - 27
Solen fishing - - - - 79
Somatogyrus - - - 23
Species, definition of - - - 145
Specific names, authority for - 146
Specimens, packing - - - 130
preparing - - - 129, 130
shipping - - - - 130
Sphærium - - - - 8, 56, 78
young of - - - - 56
Spirula - - - - 135, 136
animal of - - - 135

	PAGE
Spirula, lævis	145
Spisula solidissima	78
Spondylidæ	74
Spondylus imperialis	74
Sponge, boring	72
Spout, fishes	79
Squids	125–131, 137, 138, 139, 147
anatomy of	129, 130
beaks of	128
external parts of	127, 128
fishing for	137
flying	138
food for other animals	138
food of	138
giant	138, 139
giant, capture of	138, 139, 140
inkbag	126
how to prepare	129
pen of	129
sucker of	128
Starfish	85
Stony algæ	87
Strepomatids	20
Strombidæ	102
Strombus gigas, animal of	102
leaping of	102
uses of	102
Stylifer	124
Succinea	31
ovalis	31
retusa	31
Suckauhock	110
Tagelus gibbus	67
Tanganyika, lake	22
Technical terms	153
Tectibranchiata	105
Teeth, cardinal	3
lateral	3
of snails, classification of	41
of snails, mode of examination of	40
of snails, number on radula	43
of snails, parts of	41, 42, 43
Tellen, pink	71
shells	70
sunrise	70, 71
siphons of	71
Tellina radiata	71
tenera	71
Tellinidæ	70
Temple of Serapis	77
Terebridæ	102
Teredo, boring in wood	81
navalis	80
Testacella	37, 49, 50, 51
Tetrabranchiata	137
Tongue of snails	39, 40
Tresus nuttallii	79
Tridacna gigas	70
squamosa	70
Tridacnidæ	70
Tritonium tritonis	123
Tritons	123
Trivia exigua	107
Trochidæ	97
Trochus	22
niloticus	97
Turban, green	98
Turbinella pyrum	120
Turbinellidæ	120
Turbinidæ	97
Turbo chrysostoma	144
marmoratus	98
petholatus	98
sarmaticus	98
Turk's cap	98
Turricula	103
Turritella	100
Uhl-lo	110, 111
Umbilicus	26, 27
Umbo	2
Unio	2, 9
section of shell of	56
thick shelled	9
thin shelled	9
Unionidæ	72
Univalves	12
Urosalpinx cinereus	84
Veliger larva	93
Valvata	36
Variety, definition of	145
Vela	93
Veneridæ	69
Venus comb	111, 112
mercenaria	110
spiny	69
Vermetus	100
Veronicella	52
Vitrea cellaria	46
indentata	30
hammonis	30
Vivipara	21, 22
contectoides	21
intertexta	17
Viviparidæ	20
Voluta musica	120
Volutes	120
Walrus, clams as food of	79
Wampum	110, 122

	PAGE
Water-breathers	15, 36
Water-strider	35
Water, surface film of	35
Watercress	37
Weirs	125
Wentle trap	115
Whelk	110, 112, 122
almond	122
red	122
white	122
Winkle	110, 131
Wompum	110
Worm, clam	85
Xenophora	101
conchyliophorus	101
Yoldia	77
Zone, Coralline	87
Laminarian	87
Zonitoides arboreus	30
minusculus	30

University of St. Francis
GEN 594 B1675
Baker
Shells of land and water
3 0301 00021572 9

C0-AVU-926